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TWENTY-FIVE YEARS OF BACTERIOLOGY: A FRAGMENT OF MEDICAL RESEARCH[1]

IMMUNITY

JUST a quarter of a century ago, that is in 1895, the announcement was made at the 67th meeting of the German Society of Naturalists and Physicians that diphtheria, one of the most severe and fatal diseases of mankind, had been conquered by means of an antitoxin. This great event is a landmark, not alone in the history of medicine, but also in the history of the world, and it provides a high peak of achievement from which the growth of bacteriology may be viewed. In order that we may follow the growth with understanding, it is necessary, at first, to cast a glance backward before we begin on the narrative, the aim of which is to bring us to the state of knowledge of bacteriology existing in our own day.

Since disease is so universal a phenomenon and communicability from individual to individual so obvious an incident of its epidemic prevalence, the conception of a *contagium vivim* or *animatum* and hence of an invisible form of life as the initiator of the condition, can be traced far back in the written records of human events. And yet it was not until about 1850 that a microscopic body, which we would now call a bacterium, was actually detected in the blood of a sick animal. The anthrax bacillus, as it has since been named, which is now recognized as the inciting microbe of splenic fever, was destined to play a leading part in the development of the future science of bacteriology, but at this early period its full meaning was not perceived. When, however, in 1863 Davaine succeeded in communicating splenic fever to a

[1] Address of the president of the American Association for the Advancement of Science, Chicago, 1920.

healthy animal by the direct inoculation of blood containing the anthrax bacillus, the science of bacteriology may be said to have been born.

The dates are significant to one who wishes to follow the march of events which brought the greatest master of all, Pasteur, into the field of microbiology and led him on to the study of the infectious diseases, first of animals and then of man. For on looking backward we find that coincidental with Davaine's epochal experiments, Pasteur was already engaged on those studies of fermentation and putrefaction which were not only to set our conception of those processes on a secure biological foundation, but as an important side effect were to demolish, once and forever, the elaborately constructed but insecurely based doctrine of the spontaneous generation of microscopic forms of life.

For Pasteur it was but a step, although for us one of the highest importance, from the studies in fermentation and putrefaction to those on the infectious diseases in which, indeed, the great triumphs he achieved consist far less in the detection of new kinds of microbes to which the various contagious diseases might be described, than in his fundamental discoveries in immunology, or the science of the specific prevention of disease.

This work in the field of immunology, first opened to experimental investigation by him, is the aspect of Pasteur's labors to which I wish especially to direct your attention, since it forms the connecting bond between the earliest and thus the oldest, and the present and thus the latest discoveries in a field in which medical science has come to secure some of its most notable successes. There can be no doubt that the discovery in 1880 of the artificial immunity to fowl cholera came not as a direct incident, but rather as an accidental circumstance to the experiments being pursued. In after years Pasteur loved to point out the importance of the "prepared mind" as a requisite of the investigator, in order that he may seize hold of and utilize in respect to a question propounded by experiment what, viewed superficially, appears to be only an indirect and misleading answer. The advances leading rapidly from the artificially induced immunity in fowl cholera to the dramatic and historically and economically important immunity in anthrax and to the humanly important immunity in rabies, involved no strictly new conceptions on Pasteur's part. They consisted merely of the carrying forward of the ideas, often ingeniously modified, derived from the study of the sources of the condition of immunity in fowl cholera.

But should we inquire to what order of events already known this phenomenon of artificial immunity belongs, we should say at once probably to the order having to do with the Jennerian vaccination against smallpox. As every one knows, vaccination against smallpox consists in the utilization of human smallpox material which has become modified by passing through the cow, in which it sets up the condition named cowpox. When this modified microbic virus of the disease is returned to man, a mild form of smallpox is induced, which suffices through a term of years to protect the individual vaccinated, so-called, from infection with the more active or virulent smallpox virus.

The significance of the new observations was grasped by Pasteur and related to Jennerian vaccination. His great discovery then consisted in the determination that pathogenic or disease-producing microbes may be modified otherwise than by passing through foreign and relatively insusceptible animal species, and that such simple agencies as long cultivation *in vitro* (fowl cholera), high temperatures and therefore non-optimal conditions of growth (anthrax), and partial drying of the animal material carrying the microbe (rabies), would suffice so to modify and attenuate the respective microbes that upon inoculation they set up not the severe, but only mild states of infection, from which not only does recovery ensue, but the restored animal is enduringly protected from the ordinary and often fatal attacks of a disease.

Looking backward from our present higher position of vantage, we may discern certain

minor imperfections in this fundamental work on artificial immunity. For example, it would now appear that the so-called attenuated cultures of the bacillus of fowl cholera, used for purposes of immunization, were not so much attenuated as actually dead, and that the material inoculated consisted of a mixture of dead bacilli and their metabolic and disintegrative products. In other words, it seems that Pasteur without perceiving it had discovered not only a principle of wide applicability in inducing artificial immunity, but a general method of utilizing dead bacteria as vaccines, and one which in more recent times has been widely resorted to in preventing outbreaks of typhoid fever, cholera, and some other diseases.

In 1882 antirabic inoculation was perfected. Pasteur had, of course, reflected deeply on the sources of the immune state and in explanation of it he inclined to the view that the basis of the phenomenon was a nutritive condition. He conceived that in the course of that form of microbic development within the body which came to a spontaneous end and left the individual protected, certain essential foodstuffs were consumed, in virtue of which the same variety of microbe could not later gain another foothold. Time has not upheld this simple conception; but when it was formulated the subject matter of bacteriology was still too fragmentary and scanty to point to the deeper underlying chemical and biological processes involved. Indeed, nearly ten years elapsed until Behring's discovery of antitoxic immunity brought about a revolution in the prevailing ideas and opened up new and fascinating vistas of research.

We have now reached the period at which the German school of bacteriology, led by Robert Koch, has arisen beside the French. Koch's career in science was meteoric. From an inconspicuous country practitioner he became, in the period beginning about 1880, the outstanding world figure in bacteriology. But his greatest work was completed in relatively few years, although that of his pupils has continued up to and is still potent at the present day. It is informing to reflect that just as Davaine made the first signal advance in the experimental inoculation of disease with the anthrax bacillus, and Pasteur the first dramatic demonstration of the practicability of protective inoculation with bacterial cultures also with that bacillus, Koch rose into fame through the study of its life history by direct observation under the microscope. But Koch's greater contribution to bacteriology consisted of a method of cultivation so perfected that pure growths of bacterial species were readily obtainable. The consequence was that in a very brief period of years a whole host of pathogenic bacteria or incitants of diseases of man and animals was secured, among which were the highly important bacilli of tuberculosis, cholera, typhoid fever, diphtheria, tetanus, dysentery, plague, meningitis and many others.

Up to the period we are now considering, all the diseases of microbic origin thus far investigated successfully belonged to the class in which the bacteria invaded the blood and the internal organs. But now we are about to learn of another kind of disease induced by a class of bacteria which are peculiar in that they do not migrate throughout the body but remain fixed in a special tissue or part, where they multiply and secrete a poison which finds its way first into the lymph, then into the blood and the organs generally. This latter class of microbes produces its effects to which we give the name of disease, and of which diphtheria and tetanus are examples, through the operation of a poison, peculiar to each, and in each instance attacking by preference certain definite organs or parts of them. Thus the poison elaborated by the diphtheria bacillus selects especially the lymphatic organs, heart and nervous system for its action, and the tetanic poison the nerve cells governing muscular contraction.

We have now returned by a route somewhat circuitous perhaps to the point from which we started, namely diphtheria and its antidote. But in the course of the journey we have taken, new points of view have been gained which, as will appear, are to transform en-

tirely the outlook upon the problems that bacteriologists set themselves to solve.

Behring and Kitasato chose the task of inducing in animals immunity, to diphtheria on the one hand and to tetanus on the other. This was a logical undertaking and one clearly in the spirit of the times. Both men had a strong interest in the quest. The one (Behring) was deeply engaged in the investigation of the chemical disinfectants and conceived ideas of modifying bacterial growth through these agents, as Pasteur had succeeded in accomplishing with physical means. The other (Kitasato) had succeeded where his predecessor and the discoverer of the tetanus bacillus, Nicolaier, had failed in obtaining pure cultures of that microbe. Moreover, the restricted local development of the two bacilli and their generally poisonous or toxic effects aroused in them an eager interest intensified by the epochal discovery just made by Roux and Yersin that the toxin of the diphtheria bacillus was readily separable from the bacilli producing it and could be obtained by precipitation in, it is true, an impure state but one in which its poisonous action was preserved. Indeed, so appalling did its poisonous effect prove to be that these investigators could not imagine any other non-living substance than an enzyme which could exhibit such active properties.

The isolation of the diphtheria toxin, quickly to be followed by the similar isolation of the tetanus toxin, was an event of capital importance and reacted at once vigorously on the chemical aspects of bacteriology just struggling into the light. The immediate effect of the study of the new poisons, called toxalbumins, was to discredit a whole series of pure, crystalline basic substances obtained not long before from a wide variety of bacteria, to which the name of ptomaines had been given. Many of the ptomaines were possessed of poisonous properties; but what was disconcerting was that very diverse bacteria might yield identical chemical compounds which, therefore, lacked the property of specificity, an essential quality of bacterial activity. The toxalbumins, on the other hand, which even to this day have not been secured in a chemically pure state, exhibit in perfect degree the property of specificity and display all the power for evil and all the potential possibilities for good which their original and respective bacilli possess; and although no method of chemical identification of their special nature is available, yet their pathological effects and immunological activities serve readily and accurately to distinguish one from the other and to indicate their origin.

The rendering of animals immune to diphtheria, on the one hand and to tetanus on the other, proved a difficult but not impossible task. The method adopted was to admix disinfectant chemicals, of which the one finally selected was iodin trichlorid, with the bacilli to be injected under the skin of animals, or with the contents of the culture flasks at the end of the incubation period. Obviously, the intent was to moderate the poisonous action of the inoculated material, in the hope that a mild and not fatal infection would be induced from which recovery would follow leaving the treated animal immune.

The experiments were sometimes successful, and as such seem merely to illustrate a variation of the Pasteurian method of inducing immunity which, as we saw, was not distinct in principle from the Jennerian vaccination. But the break with the past was none the less imminent, for Behring's next act was not to speculate on the theory of immunity but to perform a decisive experiment. It is to be kept in mind that in the poisons or toxalbumins of diphtheria and tetanus, we possess the essentially active ingredients of the respective bacilli and that the body attacked does not succumb to the invading bacilli but to the action of the toxins. Hence, Behring turned to the blood of the immune animals and tested it for neutralizing power against the poisons, and discovered antitoxin; he injected the blood of an immune into the body of a normal animal prior to inoculation and discovered passive immunization; and finally, he injected the blood of an immune animal into animals previously inoculated with the bacilli

of diphtheria and tetanus, and discovered serum therapy. The day for speculation on what constituted the immune state had now definitely passed, and the time had arrived for subjecting the phenomenon to experimental study.

The fluids or "humors" of the body, to employ a term made respectable by age, as represented by the serum of the blood, had been shown to carry the immunity principles, but what part did the cells of the body play in the process? Both fluids and cells were now submitted to rigid and ingenious scrutiny, and about them an immense literature has grown up. Soon the students in the field divided into two camps, namely, one led by Ehrlich, defending the humoral doctrine, the other led by Metchnikoff, urging the cellular or phagocytic doctrine. The conflicts which raged about these concepts were always animated and sometimes even bitter; but the ultimate effect was to extend rather than to retard and confound knowledge. We are moving now in more peaceful times, the heat of the earlier conflicts having largely subsided, and it may be stated that neither the one nor the other doctrine finally triumphed, but that the humors or fluids of the body on the one hand and the cells on the other have come to be recognized as the active participating factors in the immunity process, the one complementing the other. Where the phenomenon is one purely of the neutralization of a poison or toxin, the fluid portion of the blood suffices; where also the process is relatively the simple one of acting on and dissolving a bacterial cell, there also the fluid may suffice, although an essential element in the process may have been supplied by the white blood cells at the moment of their withdrawal from the body. But where the bacteria are not readily disintegrated and dissolved, there the phagocytes of the blood and tissues come into play and, through their power of engulfing these particles, operate as one of the body's main defenses against infection.

The unravelling of the intricacies of the immune state, following upon the work of Behring, has brought about a sudden and unprecedented enlargement of the scope of bacteriology, as well as supplied a wealth of new facts of which many have permanently enriched practical medicine and opened new territory to profitable exploration. It may suffice at this point merely to mention certain of the devices for diagnosis and means of preventing or of treating disease, which are the immediate heritage of studies in the field of immunity, of which many have come not as direct fruits, but as invaluable by-products of the search. In this manner have been secured the Widal test for typhoid fever, the Wassermann and allied reactions, the hypersensitive or Schick test for diphtheria susceptibility, the hypersensitive reaction as now applied to the detecting of the offending agency in hay fever and allied states, the refinements of bacterial vaccination in the prevention and sometimes in the treatment of disease, and so-called specific serum therapy. Moreover, these studies have placed in the hands of the bacteriologist a powerful instrument for detecting, through immunity reactions carried out in test tubes, or the animal body, new varieties of pathogenic or disease-producing bacteria and of investigating more closely and sorting out groups of pathogenic microbes not hitherto subject to analysis. Finally, the immunity reactions, as they are generically named, have been found not to be restricted to bacterial cells and poisons, but to apply to a wide variety of cells and their products. For it should be recalled that in the decade immediately succeeding the discovery of antitoxin, agglutinins, precipitins, bacteriolysins, cytotoxins, hemolysins, complements, chemotaxis, anaphylaxis, and the minutiae of phagocytosis were discovered and became the objects of animated and often feverish and sometimes controversial but always profitable investigation.

It happened also and quite naturally and logically that this should be the heyday of hypotheses concerning the biological basis of immunity and the manner in which interaction takes place between toxin and antitoxin inside as well as outside the body, and of the englobing of bacteria and other bodies by the blood and tissue cells, as well as the nature of

the combinations and permutations and reactions between the more complex bacteria and cells in course of their immunological transformations. And thus there came to be elaborated the side-chain hypothesis of Ehrlich, which vied with the phagocytic theory of Metchnikoff as well as with the adsorption theory of Bordet and the physico-chemical theory of Arrhenius. And if in our busy lives of to-day we think less of receptors and amboceptors, of complements and complementoids, haptophores, and toxophores, and limit ourselves somewhat more closely, perhaps even a little too exclusively, to the observed fact itself, yet it is well that we do not forget how great at the time was the stimulus to research and how rich the booty which accrued from those labors tinged with the radiance of the real scientific imagination of an Ehrlich, a Metchnikoff, and a Bordet.

Not all the high expectations of practical benefit to follow from these discoveries have been realized, but sometimes the very failures have been turned to account in opening up new, or illuminating old, avenues of progress. In this connection it is instructive to recall the early pronouncement of Behring made two years after the discovery of antitoxin, and while he was under the influence doubtless of that great contribution:

"The present state of the immunity question," he says, "may be defined as follows: Thus far no generally applicable explanation for natural immunity has been forthcoming. But of the artificially produced immunity it may be said that the precise study of a number of examples has so far advanced our knowledge that we may assert with confidence that the immune state arises from a peculiarity of the blood and, indeed, of its cell-free portion; in no instance in which a sufficiently high grade of immunity has been attained in an animal species, easily susceptible to the infection in question, has the blood withdrawn from the body failed to show evidences of the presence of the immunity-conferring substances."

In this statement will be perceived the extreme humoral view of the origin of immunity, which subsequent investigators failed to uphold. But he continues in a prophetic vein, unfortunately likewise destined not to be wholly fulfilled.

"With the achieving of this standpoint the next step in the winning of specific curative agents for the infectious diseases is clearly outlined: all that is required is the induction in a susceptible animal species of a high degree of artificial immunity, and then to test the blood for the presence of protective and healing substances."

Time has exposed the fallacy of this overconfident attitude and taught the distinction between the two varieties of infectious disease and their corresponding immune states, according as their main effects and symptoms arise from the toxalbumins or poisons we have been considering, or the intimate presence within the organs of the microbes themselves. The former variety chances indeed to be in the minority, and hence it has come about that the diseases to be successfully combated by antitoxins are few in number, while those in which the microbes penetrate deeply into the body and which poison its tissues by means of so-called endotoxin, are far more numerous. The latter class includes such important diseases as tuberculosis, typhoid fever, meningitis, plague, cholera, the septicemias, and still others. And yet the failures have been only partial, and success has been and is still being won against odds which were once considered insuperable.

What is striking is the capriciousness with which the microbes themselves or their endotoxins lend themselves to the making of therapeutically effective serums, as contrasted with the ease and certainty of action in this respect of the toxalbumins. All the latter seem capable of yielding abundant antitoxins, and this independently of their precise source, since it happens that toxalbumins resembling those of bacterial origin exist also in the higher plants —as in the castor and jequirity beans—and in the venoms of reptiles and insects. On the other hand, it has not thus far been found practicable to fashion curative serums for tuberculosis, typhoid fever, plague, cholera,

etc., while success has been achieved in the instance of epidemic meningitis, and very hopeful results have recently been attained in the case of pneumonia.

In meningitis the success is linked with the recognition of a second principle of action, namely the advantage to be derived from what may be called the local specific treatment of a disease, or the bringing of the healing serum into direct and intimate relation with the seat of the infection itself. Since in epidemic meningitis it is the membranes surrounding the brain and spinal cord and those more delicate ones lining the cavities of the ventricles of the brain which are the seat of infection, it has been found easily possible, through a simple and safe procedure, to inject the serum into the cavity of the spinal meninges, whence it is quickly distributed over all the membranes of the brain and cord. It may be of interest to remark that it is not practicable to reach the inflamed membranes with the serum by way of the blood, since nature, in order to protect the sensitive nerve tissues from injury by any chance deleterious substance in this fluid, has interposed an impenetrable barrier, the choroid plexus, between the circulation and the cerebrospinal fluid which bathes and sustains the nervous organs, and which is itself elaborated from the blood by this plexus with an accuracy of selectiveness highly remarkable.

In pneumonia again a beginning success has been achieved through a finer discrimination of specific kinds among the pneumococci, the inciting microbes of the disease. This distinction is independent of ordinary physiological and cultural characters displayed by the bacteria, which do not serve to bring out the underlying specific properties of each, and has been accomplished by means of the so-called immunity tests carried out in test tubes or in the animal body. The gain to practical medicine from the detection of the fundamental differences subsisting between the three main types of pneumococci existing in this country has been very great. Already a curative serum for one of the specific types of pneumonia has been secured, and through its application many lives have been saved; while beginnings have been made in respect to vaccination against the disease when, as sometimes happens in institutions and in communities, epidemics prevail and claim many victims, as occurred in the Army training camps during the measles epidemics of 1917–18.

Thus we have learned that the immunity reactions, or the effects on bacteria and their poisons, of the fluid and cells of the body as modified by the process of artificial immunization, provide more delicate and precise means of discriminating bacterial species than the qualities of form, growth appearances and physiological activities, and more accurate methods of distinguishing poisons than the most refined chemical analyses; and we shall learn a little later in connection with the distinct but related hypersensitive or anaphylactic state, that the prepared and sensitized animal body responds to infinitesimal amounts of protein matter according to its specific origin, in a manner not otherwise determinable and far beyond the most delicate laboratory test which the chemist has invented. The animal body thus artificially prepared, or as sometimes happens naturally sensitive, acquires an appreciation of the inner constitution of the protein molecule, classifying it, as it were, not only according to its ordinary chemical nature, but according to its species origin.

The immunity reactions we have considered are not artificial creations, since as we now know, they are the very processes which nature employs in her unaided efforts to abate infections, and when need be, to adopt the body to foreign proteins. The spontaneous recovery from infectious disease, by which is meant merely that the body by its own power overcomes the microbes and their poisons, depends upon the setting into motion of the series of operations through which immunity responses in fluids and cells are insured, precisely as has been described in the event of an artificial immunization. Hence in our efforts at serum therapy we aim merely to aid "nature," by introducing, as it were, into the beset body the finished immunity products artificially pro-

duced in healthy animals; and in protection by vaccination, success is assured only to the extent to which the healthy body has been compelled to prepare the specific immunity substances and to hold them ready at hand to combat the entrance through its outer gateway of, for instance, such microbes as those inciting typhoid fever and smallpox.

That it is through the prowess of the body itself, and not the skill and art of the physician, that recovery from infectious disease takes place, had already become evident to the ablest physicians of nearly one hundred years ago. It is true that they could form no real conception of the manner in which the cure was brought about, but in admitting the existence of a class of maladies which Jacob Bigelow in 1835 called the "self-limiting diseases"[1] this innate faculty of the organism to overcome infection was recognized. It may be of even more than historical interest to reprint here the pregnant paragraph in which Bigelow expresses this view:

> This deficiency of the healing art (he is now writing of the advances in knowledge of the structure and functions of the human body in contrast to the lagging behind of the science of therapeutics, or the branch of knowledge by the application of which physicians are expected to remove diseases) is not justly attributable to any want of sagacity or diligence on the part of the medical profession. It belongs rather to the inherent difficulties of the case and is, after abating the effect of errors and accidents, to be ascribed to the apparent fact that certain morbid processes in the human body have a definite and necessary career, from which they are not to be diverted by any known agents, with which it is in our power to oppose them. To these morbid affections, the duration of which, and frequently the event also, are beyond the control of our present remedial means, I have, on the present occasion, applied the name of the *self-limited diseases;* and it will be the object of this discourse to endeavor to show the existence of such a class, and to inquire how far certain individual diseases may be considered as belonging to it.

ANAPHYLAXIS

Allusion has several times been made to the hypersensitive state which is often regarded as the opposite of the immune condition. Because the latter is conceived as protective and hence is spoken of as being prophylactic, the former in turn has been named anaphylactic. The obvious distinction between the two conditions is simply defined by the statement that while the immunized animal shows a greater degree of resistance to a second inoculation of the materials used for immunization, the anaphylactized animal on the contrary shows a heightened susceptibility.

The history of anaphylaxis illustrates the manner in which the rapidly growing knowledge of immunity reacted on the appreciation of this condition. It now appears that the physiologist Magendi, who flourished in the first quarter of the nineteenth century, first noted that an animal which had borne without apparent effect one injection of a quite harmless protein such as egg white, reacted severely to a second injection of the same kind of material given after an interval of days. No further contemporary attention seems to have been given to this isolated incident, and it was not until 1894 that the speaker chanced again upon the phenomenon. He was engaged upon a study of the pathologic action of the toxalbumins, and his attention was attracted by recent experiments on the similar globulicidal (or red blood corpuscle destructive) action of certain alien blood serums, such for example as the serum of the dog for the red globules of the rabbit. Since animals could be rendered immune to the toxalbumins, the attempt was made to make rabbits immune to dog's serum, but without success. On the contrary, it was found that animals which had withstood one dose of dog's serum succumbed to a second dose given after the lapse of some days or weeks, even when this dose was sublethal for a control animal.

Again the observation fell on stony soil, as indeed subsequent ones were destined to do a few years later and, as it now appears, chiefly because knowledge of and interest in the general subject of immunity had not progressed far enough at that period to present to the contemplation of the "prepared mind," to use

[1] Jacob Bigelow, "Discourse on Self-limited Diseases," Boston, 1835.

Pasteur's phrase, the sharply contrasted hypersensitive state.

But the time for the systematic investigation of the phenomenon was approaching, for between 1902 and 1904, Richet and his pupils had their attention arrested by an extraordinary incident, as it then seemed. In undertaking to effect immunization with certain poisonous proteins of animals, they found that instead of inducing resistance, they induced hypersensibility. To this latter condition they applied the name anaphylaxis. Although as it subsequently turned out, the idea involved misconception of the nature of the process, yet these studies stand forth illuminatingly as recognizing for the first time the dependence of the hypersensitive state upon a preceding injection of a given protein substance and the necessity of an incubation period covering a number of days between the injections, in order that the sensitive condition might be ushered in. That the sensitizing effect was of the nature of a general biological reaction of the animal body to the parenteral introduction of natural proteins into the body, without reference to their primarily poisonous character, came to be appreciated a little later as the result of observations made on rabbits and guinea pigs injected and then reinjected with horse serum, as well as with other innocuous proteins. In order to arouse the reaction of immunity in the animal body, some degree of primary poisoning of the cells, as with bacteria, their metabolic products and similar substances originating in other varieties of living beings, must be accomplished; while the sensitive state arises from the interaction of the animal body with any native protein substance whatever which finds its way directly or indirectly into the blood.

From the many investigations which now ensued, it appeared that while many kinds of warm blooded animals are subject to the condition, yet the most striking, because most uniform and dramatic effects are yielded by the guinea pig, which has since become, as it were, the "classical" animal for observing and studying anaphylaxis. The reason for this choice arises from the circumstance that in the guinea pig a sensitization of the smooth muscle fibers occurs, so that on reinjection of the original protein, among other effects, a contraction of the lining membrane of the bronchi takes place, which by closing their lumina and excluding air, quickly causes death from asphyxiation. Moreover, the guinea pig has proved exquisitely responsive to sensitization, so that minute quantities, measured even in fractions of milligrams, of pure native proteins suffice to induce a specific hypersensitive condition, whence it has followed that the prepared guinea pig has been found suitable for the investigation of the ultimate chemical relationships, not otherwise observable, which subsist between native proteins.

Profoundly different as are the obvious features of the anaphylactic and immune reactions, yet certain of the fundamental conditions governing both coincide. It will be recalled that in arousing immunity in animals by artificial means, certain new substances of the general nature of antipodes, or as technically named, antibodies, are made to arise in the blood of the treated animal; and it now appears that in the course of sensitization of animals, antibodies to the proteins injected also develop. In both instances the material originally injected, whether primarily poisonous or not, if active, belongs to a class now called antigens, that is generators of antibodies. The expression of the immunity reaction, in its simplest terms, consists of a chemical or physico-chemical union between the original antigen and the manufactured antibody, taking place in the body or in a test tube, through which the primarily poisonous antigen is rendered innocuous. In other words, the immune antigen-antibody complex is a harmless compound.

In a similar manner the sensitizing antigen and induced antibody unite in anaphylaxis, but the product of the union is essentially different from the one just considered, in that it is highly injurious, and the effect of the antigen-antibody complex is not to protect, but to poison the animal. The basic distinction between the immune and the anaphylactic condition, as described, is further enforced when

we recall that the original toxic protein used to immunize is detoxicated in the course of the immune reaction and the original non-toxic protein used to sensitize is endowed with the property of intense toxicity in course of the latter reaction.

As in the instance of the immune state, a still undecided controversy is going on as to whether the hypersensitive condition depends upon humoral or upon cellular factors. There is no doubt that the anaphylactic antibody exists free in the blood, and hence that a normal animal can be rendered passively sensitive by the infusion of blood derived from a sensitized animal. It is equally true that the anaphylactic response is in part a cellular one, as in the instance mentioned of the bronchial musculature stimulated to contraction. By appropriate experiments it can be shown that organs containing smooth muscle taken from sensitive animals, exhibit the equivalent of the anaphylactic reaction even outside the living body; and also that coincidentally with the appearance of the "shock" of the reaction in the guinea pig, the blood becomes incoagulable.

Hypersensitiveness may exist independently of purposive artificial sensitization, and some of the most important examples of that condition have been observed in man. Because of their size, perhaps for other reasons, human beings even when sensitive react to the parenteral injection of native proteins less severely than the smaller animal species. And yet lamentable instances, if very few in number, of serious or even fatal anaphylactic effects have been observed in man. These have occurred especially in connection with the therapeutic employment of curative serums derived from the horse. The greatest danger from this source is at the time of the first injection, for while severe effects do sometimes follow upon a second or subsequent injection, they have never been attended by fatal consequences. Luckily, means are known for anticipating these even infrequent accidents, and of guarding against their dangers without at the same time depriving those in need of the benefits of serum protection or therapy.

Beside the active state of sensitization another is known which may be termed negative. Thus it has been found that when a sensitive animal is given an injection of a protein which produces a certain degree of anaphylactic effect, but not a fatal outburst, the treated animal can for a time be rendered insensitive. And thus human beings who are sensitive, say to horse serum, may be desensitized by means of successive small inoculations of the diluted serum, and while in the refractory state thus induced receive without risk larger injections of the serum.

On the other hand, lesser states of anaphylaxis in man are by no means infrequent. To them belong the rashes of "serum sickness" following the injection of curative serums which while annoying are not dangerous, and the very disagreeable manifestations of hay fever and its allied conditions, now attributed to the action of vegetable materials, pollens chiefly, upon the sensitized mucous membranes of the nose and throat. Recent studies by Auer have shown that animals sensitized with harmless proteins, such as horse serum, develop severe local inflammations when from any local cause an extrusion of the antigen-containing fluid of the blood is enabled to penetrate the extravascular tissues; and on the basis of this observed fact he has suggested that functional disturbances of many organs of the body in sensitive human subjects may be brought about in a similar manner.

In a related field the hypersensitive reaction has been employed to aid in the diagnosis of important diseases of man and animals. It is apparent from what has been stated of the site of the fatal anaphylactic shock in the guinea pig, and as stated a moment ago of the sensitiveness of tissue cells in general to the circulating anaphylactic antigen, that a visible local reaction might be obtainable by introducing the protein to which the animal or person is sensitive into a visible portion of the body, as say the skin. In this way sensitiveness is looked for before serum injections are given, tuberculin is employed to disclose hidden foci of active tuberculosis, luetin is used to expose evidences of latent syphilis, and, in a modified manner, the Schick test is applied to determine

whether exposed children do or do not carry in their blood, spontaneously as one might say, sufficient diphtheria antitoxin to afford them security without a protective serum injection. And beside the benefits accruing to human therapy directly from the working out of the meaning of anaphylaxis are to be placed those improvements introduced into veterinary practise, from which human preventive medicine also has derived great gain, namely, the application of the tuberculin test in clearing milch herds of actively tubercular cattle, and of mallein to the controlling of glanders among horses.

FILTERABLES

As we move from the contemplation of one achievement to another in bacteriology, we rarely pause to reflect how far circumstances almost accidental have favored the gains. The working out of the biological basis of fermentation and putrefaction, and a little later of the microbic origin of disease, is obviously bound up with the perfection of the compound microscope, and the usefulness of that instrument for the purpose is as obviously bound up with the ultimate size of bacteria and related organisms. And yet without the fortunate conjunction of an optical device and the degree of magnitude of living objects, we should still be groping in outer darkness in the search for the origin of disease, and still struggling with the phantoms of spontaneous generation. But the great men who proved the connection between microscopic life and the biological processes mentioned, including the source of the infectious diseases, did more than describe the phenomena revealed by the microscope and otherwise. They established methods with principles so clearly enunciated and rigidly based that it has been found possible to penetrate into an inhabited territory in which thus far the most powerful microscope has not always enabled us to discern the living forms.

Thanks to their labors we know now, first, that the faculty of setting up disease in successive individuals is a property only of matter which can itself increase indefinitely, and all matter thus constituted is possessed of life; and second, that certain disease producing parasites can be separated mechanically from the soluble products of their growth, by passage through earthenware filters, in which the interstices or pores are smaller even than the size of the microbes themselves. By varying the density or porosity of these filters, we arrive at a way of roughly estimating the size of the microbic cells.

Thus it came about that in 1898 two German bacteriologists, Loeffler and Frosch, who were engaged on the study of the very highly communicable foot and mouth disease of cattle, discovered that after diluting the contents of the unbroken vesicles which arise in that disease, with 20 to 40 times their volume of water and passing them through such earthenware filters, the filtrate not only would induce the disease on inoculation, but that the same series of events followed the dilution and inoculation of the vesicular contents of the experimental variety of disease through an indefinite series. Obviously the filtrate contained a living element which came to be called a virus, just as is the smallpox germ, for in neither instance, and notwithstanding laborious endeavors, has the living organism itself ever been seen under the microscope.

We now recognize a class of microbes or viruses which are so minute as to be regarded as ultramicroscopic, and yet so active as to be capable of setting up disease in animals and man. The precise limits of the class have yet to be defined. When we consider that there remain still to be detected the microbic incitants of some of the most contagious as well as common of diseases, our minds readily seize hold of the possibility of their being of this nature. Thus the microbes responsible for such contagious maladies as measles, scarlet fever, and chicken pox, and those inducing smallpox and rabies are not known, and not a little obscurity still surrounds the etiology, as we say, or immediate origin of epidemic influenza.

Inasmuch as the filterable microorganisms or viruses, or filter passers as the British prefer to call them, are known alone through their disease-producing propensities, no one can say whether, as is true of the bacteria, in-

numerable kinds exist in nature, among which relatively a small number has acquired parasitic or pathogenic qualities. Of the less than a dozen diseases known or on good grounds considered to be induced by filterable microorganisms, two attack human beings, namely poliomyelitis or infantile paralysis, and trench fever; and a third, yellow fever, which until very recently was believed to belong also in this category, has now been relegated to another class, with respect to which special devices suffice to bring into view its microbic incitant.

There exists, therefore, a degree of uncertainty in this field of research for which allowance must be made, since it may well happen that suddenly through a fortunate series of experiments or the opening up of new methods, a parasite hitherto regarded as invisible may be brought into microscopic view. Should, for example, complete evidence be brought forward to relate the Rickettsia bodies to certain specific infectious diseases transmitted especially by insects, as by the wood tick in Rocky Mountain spotted fever, and lice in trench and typhus fevers, then another group will have been transferred from among the ultramicroscopic to the visible parasites. A similar situation exists regarding the globoid bodies of poliomyelitis, the disease of man most convincingly established as induced by a filterable microorganism. By means of a highly specialized method of cultivation applicable especially to the class of spiral microbes, or spirochetæ, Dr. Noguchi and the speaker isolated from the nervous organs of cases of poliomyelitis, globular bodies so minute as to be just at the limit of visibility under the highest power of the microscope. With cultures of these bodies they induced experimental poliomyelitis in the monkey; but the culture method itself is so intricate that thus far few bacteriologists have been able to repeat the work, which therefore still awaits final confirmation.

Since the recent pandemic of influenza and the assault made upon the so-called influenza bacillus of Pfeiffer, isolated first in Germany during the influenza epidemic of 1889–1890, the inciting microbe of that disease has been sought among the filterables. The announcement of the finding of such a parasite in the nasopharyngeal secretions by Nicolle and Lebailly of Paris in the autumn of 1918, aroused high hopes which subsequent investigations have not served to sustain. The problem was approached in a somewhat different manner by two workers—Olitsky and Gates, at the Rockefeller Institute. Their studies embraced two periods, the epidemics of 1918–1919 and 1920, and the intervening (interepidemic) period, the latter serving as a control for the former. The essence of their investigations consisted in injecting through the trachea into the lungs of rabbits saline nasopharyngeal washings derived within the first 24 to 36 hours after the appearance of symptoms from influenza patients and observing the effects (*a*) upon the blood and (*b*) upon the lungs. The striking changes, in the successful experiments, relate to the white corpuscles of the circulating blood which suffer a numerical depression affecting chiefly the mononuclear type of cells, and to the lungs in which multiple hemorrhages and edema, but not pneumonia, arise. The effects are correlated: where no lung lesions are found no blood alterations occur. These objective phenomena are induced by filtered materials free of all ordinary bacteria (ærobic and anærobic) and they have not been secured otherwise than with materials derived from early cases of epidemic influenza; but when present, the rabbits affected very readily become subject to the action of various other bacteria (streptococci, pneumococci, staphylococci, influenza bacilli), to which they are otherwise resistant, but which then settle in the lungs and excite fatal pneumonic affections. The unassisted action of the influenzal material is not fatal; only when an ordinary bacterial lung infection is superadded does death follow. All who are familiar with the effects in man of pure influenza and then of influenza complicated with pneumonia of pneumococcal, streptococcal, etc., origin will appreciate this distinction.

What also characterizes the class of diseases incited by the true filterable parasites is their

high degree of specificity and the enduring immunity which follows recovery from an attack. This is true among animals, for instance, of hog cholera and foot and mouth disease, and in man of poliomyelitis. This specificity is shown by the difficulty or impossibility of implanting the virus on specifically remote animals. In poliomyelitis, for example, only monkeys are subject to experimental infection, in hog cholera and foot and mouth disease, only swine and cattle. Bearing in mind Behring's dictum that to produce a therapeutic serum, it is essential to immunize highly susceptible animals, it becomes evident why success has not crowned the many undertakings to prepare an antipoliomyelitis serum in the horse or other large animal, and why it is only by the use of swine themselves that an anti-hog-cholera serum has been secured.

The investigation of this class of excessively minute or filterable parasites casts a sharp ray of light into a neighboring field of biological research which at the time aroused hopes of further rapid progress but which the intervening time and effort have not realized.

Perhaps no subject in experimental pathology has been pursued with more thought and energy than the one to which the name of cancer research is applied. The reasons are obvious. The nature of the source of the cancerous tumors is still shrouded in essential darkness. It is, of course, known that cancer sometimes follows upon prolonged irritation and inflammation of tissues variously excited. But what the immediate impulse is that calls forth the cancerous state is unknown. And yet advances have come from the study of the spontaneous and transplantable cancers in mice, rats and some other animals. A long series of biological conditions governing the growth and recession of the tumors have been uncovered, and by altering those conditions, on the one hand growth can be promoted, and on the other, retarded. In this way, Murphy and his coworkers have accounted for the influence of the action of the X-ray in affecting cancer growth; and by observing the correlative effects on the lymphoid structures of the body, which are very sensitive to the rays, and the changes corresponding to them in the circulating blood, they have so altered the scale as almost at will either to abolish or stiumlate the development of mouse cancers.

But these experimental results and others of a class in which the defensive forces of the body can be marshalled against the implanted cancer cells, throw no real light upon the series of events underlying the origin of cancer. The light referred to was shed by the studies of Rous, of the Rockefeller Institute, upon a sarcoma, or fleshy cancer, of the domestic fowl. This cancer, which arises at times spontaneously in fowl, is subject to successful implantation in other fowl. The specificity is accurate; it will not grow in other birds and grows best in the variety of fowl in an individual of which it originally appeared. Its growth is first local, as is cancer in man, and later metastatic, or, appearing at a distance and starting from microscopic masses of cells derived from the original tumor and carried by the circulation to remote parts of the body. The altogether new and unprecedented fact about this tumor, which has, however, not yet been found to be true of the cancers of mammals, is that it may be induced by the injection into the susceptible variety of fowls, of a cell-free filtered extract of the tumor. In other words, Rous has accomplished for this tumor what bacteriologists had effected for a certain refractory group of the infectious and communicable diseases, namely, relating it to a form of life not imagined by the founders of bacteriology, but which their discoveries in the field of the living microscopic, as opposed to the ultramicroscopic, universe brought within range of recent biological research.

SPIROCHETES

The vicissitudes of bacteriological science, like those of other sciences, have depended upon time and method, and sometimes the one and sometimes the other has served to promote discovery. When by a happy conjunction of circumstances, time and method happen to conjoin, then advances almost startling in nature may take place.

It is in this way that we may view the re-

markable progress of events in connection with a class of special microorganisms or spirochetae, so called since Schaudinn's discovery in 1905 of the *pallida,* the microbic inciter of syphilis. The search for the microbe of syphilis had been unremitting since the early days of bacteriology, and not a few false claimants held the field for a brief space. Schaudinn's discovery was very soon confirmed, and has now been firmly established; and it is interesting to note that in fact it was itself a confirmation of an observation made a few years earlier by Metchnikoff and Bordet, who, however, because of the technical difficulties of the quest did not succeed in confirming their own findings. The unusual difficulties surrounding the detection of the living *pallida* in the body fluids, because of its extreme tenuity merely heighten the respect we must hold for the zoologist Schaudinn's perspicacity. Very soon staining methods were introduced to lighten the task of detecting the *pallida,* but so capriciously did they act and so baffling did the ordinary microscopic detection prove, that the great promise of the employment of the *pallida* for purposes of diagnosis and treatment was not at once realized.

None the less, a great advance in bacteriology had been achieved, and a new class of microbes potentially disease-producing was presented for study. Within a year a second spirochete, called *pertenuis,* was discovered in the lesions of yaws, a tropical disease having certain affinities with syphilis. The search for the delicate spiral organisms was not an easy one, and only the masters of bacteriological technique were likely to succeed in it. Then suddenly the labor was lightened and the road made smooth for a rapidly succeeding succession of discoveries in this field by the invention and application of the dark-field or ultramicroscope. This instrument was perfected for observing dispersed particles in colloidal solutions and, as many of you are aware, operates by projecting powerful rays of light in directions parallel to the surface of the microscopic slide. Such a field if optically empty will be dark and not luminous; but if particles are present in it, the rays of light will be intercepted and the particles illuminated. They in turn, and according to their size, will appear as bright objects, or when very small, give a diffuse luminosity to the field. The phenomenon is similar to the one described by Tyndall, in which a beam of light passed through a dark space containing suspended particles causes them to become visible. When the suspended matter consists not only of dispersed particles, but of microorganisms, these also become luminous, and when, as with the spirochete, they exhibit a wavy structure and independent motion, they at once arrest attention. To-day the dark-field microscope is found in every well-equipped clinic, and it has aided in adding many new species to the already considerable number of microbes known to be disease-producing.

The latest significant addition to this field is the *Leptospira icteroides,* or the jaundice-producing spiral, which Noguchi has recently detected in the blood and internal organs of cases of yellow fever. His extensive investigations carried on in Ecuador, Mexico, and Peru, as well as at the Rockefeller Institute, have rendered it highly probable that this spirochete is the microbic incitant of that severe epidemic disease.

Yellow fever, as you know, is an insect-borne disease and arises from the insertion into the blood of man of a virus carried by a particular mosquito—*Stegomyia calopus.* After the mosquito transporting the virus has bitten a healthy person, an interval of about five days elapses before his blood becomes infective, and the infectiousness endures about three days longer. During the latter period the blood serum can be passed through the finest-grained porcelain filters without losing its infectivity. On the other hand, a normal mosquito which has bitten a yellow fever patient, does not become capable of infecting other human beings until after about twelve days. Hence the insect acts not merely passively, as a needle might, as the conveyer of the virus, but is necessary in order to increase

or otherwise modify the infective material withdrawn from the blood.

The discovery of the yellow fever spiral definitely removes the disease from the class believed to be provoked by ultramicroscopic organisms, and at the same time adds so well defined a microbe as *Leptospira icteroides* to the group of filter passers. The data so far secured regarding this spiral in relation to yellow fever fulfill the conditions arising out of Reed and Carroll's discoveries in connection with the disease in man. These are great gains for theoretical bacteriology. The rewards to practical medicine are even greater, since it has been found that *Leptospira icteroides* lends itself to the making of an active vaccine (killed organisms) and also an effective therapeutic serum. Hereafter yellow fever is to be combated (1) by removing the breeding places of the stegomyia, (2) through vaccination, and (3) by an antiserum.

The etiology, or causation, of yellow fever so long and fruitlessly sought seems to have been solved, and it may be of interest to inquire why just at this juncture? The answer is, through the conjunction of the "prepared mind" and animal experimentation. For nearly a decade Noguchi has been investigating this spiral class of microbes, in course of which he added materially to our knowledge of methods of study and of new species. He had first-hand knowledge of a related disease, infectious jaundice, transmissible to guinea pigs, which prevails endemically in Japan and sporadically elsewhere, and in which Inada had discovered a peculiar spiral organism (*Spirocheta icterohæmorrhagiæ*). In other words, the time was ripe and Noguchi peculiarly equipped to take up again and investigate with newer methods the problem of yellow fever.

The story is still incomplete, as recent developments have shown; for just as Metchnikoff and Bordet had seen the *pallida* before Schaudinn, so it now appears Stimson of the U. S. Public Health Service had previously observed the *icteroides*. He examined a series of sections of organs stained by Levaditi's method to show spiral organisms, taken from a patient having yellow fever who succumbed in New Orleans in 1907, and in the kidney found spiral forms to which he gave the name of *Spirocheta interrogans,* but the significance of which could not then be determined, and which Noguchi now identifies as the *icteroides*. Coming at this time and in this way, the observation is a welcome confirmation. Without the many data since supplied by Noguchi's experiments and studies of living cases of yellow fever, it possesses only suggestive value. The finding came too early in the development of our knowledge of the spirochete, and again the seed fell on stony ground.

There remains one further aspect of this incomplete discussion of spiral microbes in their relation to disease to be considered briefly, namely their separation into two classes according as the diseases induced by them respond to treatment on the one hand by curative serums, and on the other by so-called drugs or chemicals. It has just been stated that yellow fever can be combated by a serum of this kind, and the same is true of infectious jaundice. In this respect the two inciting microbes—*L. icteroides* and *S. icterohæmorrhagiæ*—behave as do certain bacteria. But the spirochete of syphilis and yaws and some others are not subject to serum influences, and hence they and the disease they induce must be attacked from another quarter, and in this instance with chemicals for which they evince an extraordinary selectiveness, as do the malarial organisms and certain parasitic trypanosomes which are of protozoal nature.

CHEMOTHERAPY

Chemotherapy is the name applied to the branch of experimental medicine in which chemicals, or drugs, are searched for, and when necesary and possible, fashioned to subdue a particular kind or class of infection. The beginnings of chemotherapy reach into the dim past; the science of chemotherapy is just being built up. The epochal discoveries of the curative value of cinchona bark in malaria and of mercury in syphilis, are examples of the early, and as we now say empirical working out of specific therapeutics.

But in emphasizing these two triumphs of the empiric period long antedating the experimental epoch in medicine, sight should not be lost of the essential point, namely that the virtues of those remedies were established also by experiment carried out over long decades and upon man himself, for in no other way could these active drugs have been separated from the thousands of innocuous or even harmful ones applied by man at all stages of his evolution to the alleviation of suffering.

In a strict sense, curative serums are examples of chemotherapy, and the most specific ones known, since they are so exactly adapted to combat a given microbe or its toxin, and because in the end the active component is chemical in character. But as usually employed, the term is applied rather to chemicals or drugs not produced by the animal body and of definite and ascertainable ultimate composition.

The beginnings of the experimental science of chemotherapy are very recent, and hardly more than a start has been made in exploring the field. The principle on which it is based can be expressed simply: microbic parasites on invading the animal body arouse defensive activities on the part of the host, which when of sufficient intensity serve to weaken and restrain, and ultimately to overthrow and conquer the invaders. These natural defenders, as we learned earlier, consist of fluid and cellular constituents of the body, sometimes preformed, sometimes only manufactured on demand, and in part especially adapted to the particular parasitic agent to be vanquished.

With this picture before them, of the manner of the body's defense against microbic invasion, bacteriologists could appreciate that the overcoming and healing of infection is never a mere passive process, and the action of healing agents in the body does not occur, as the older therapeutists believed, precisely as would happen if the parasitic agent could be exposed to the effects of drugs, say in a test tube. Moreover, it was always evident that such effective drugs as quinine and mercury must be employed sparingly, because while they were able to injure and thus to lead to the destruction of the microbes inducing malaria and syphilis, they were likewise capable of injuring the component cells of the body itself.

The outstanding instance in which experimental chemotherapy has registered a great success is in connection with the organic compounds of arsenic, which have been adapted to the overcoming of infection induced on the one hand by spirochetes and on the other by trypanosomes. That arsenical compounds possess therapeutically active properties against these two classes of parasitic diseases—as represented on the one hand by syphilis and on the other by African sleeping sickness—is not entirely a recent discovery; but until the systematic investigations of Ehrlich were instituted, which ultimately yielded salvarsan, knowledge was fragmentary, medical practise based on it ineffective, and the road to progress obscure. Now the outlook is wholly changed, and there is going forward an active and either already successful or at least highly promising search for new drugs or chemicals, directed against both the bacterial and the protozoal parasitic microbes. This territory so newly opened to exploration in which organic chemists and pathologists should pool interests in order to move forward, is of almost infinite possibility, since the number of chemicals is nearly limitless which can be produced and so fashioned as to injure and subdue as it were the parasitic invader, and at the same time, pass over and leave little influenced the adjacent body cells. But the conditions of the search are intricate since, as just indicated, a useful drug must exhibit high power of attack upon the protoplasm of a parasitic microbe and a low one on that of the cells of the blood and the organs, in order that the former and not the latter may be predominately affected. It is a peculiarity of chemicals as contrasted with serums that they can never be so accurately designed to their purposes as to remain entirely without effect on the cells of the host; but it is also recognized that when the drugs are effective, they do not carry on a single-handed combat, but serve best when they either assist or are

assisted by the natural defensive mechanisms of the body, which also are roused into action to overpower the invader and the cooperation of which often insures protection against reinvasion, acquired at the end of, and in consequence of, the struggle.

INFECTION AND SURVIVAL

Infection and the mastering of infection are intricate biological processes in which contending forces are brought into play one against the other, whence a struggle ensues. We have seen that the host stands ready equipped with mechanisms of defense which may be quickly mobilized, and which undergo favorable modification during infection, when as we say, it proceeds toward a favorable termination. The bacteriologist has learned within the past quarter of a century to imitate nature's method of surmounting infection by supplying certain of the defensive implements artificially wrought to be brought to her aid in time of stress and need, and the chemist is learning more and more the manner of adapting drugs to the destruction of the microbic parasites of disease for a like purpose.

All the advantage is, however, not on the side of the body, since the parasites also possess powers of modification, through which the most elaborate obstacles placed in their way by the host may be rendered futile.

These adaptations consist in the acquisition of special properties of aggressive action or virulence, with which is associated the ability to produce and liberate substances paralyzing to the defensive processes of the host. Again, the parasites may surround themselves with a kind of mantle, protecting them from the potentially destructive effects of serum and phagocyte. Or they may undergo an internal change of constitution, through which resistance to injurious agencies not normal to the species is developed. The last condition is called "fastness" and has been observed especially among trypanosomes and spirochetes exposed within the body of the host to ineffective amounts of specific serums or chemicals.

With so many factors interplaying, it is not difficult to perceive that the problem of infection is a complex one, both as regards its occurrence and its issue. But our understanding of the conditions under which it arises has been immeasurably extended by the discovery of the insect and higher animal agencies in communicating infective agents to man, and of the part played by so-called microbe carriers, those unfortunate and innocent persons who have recovered from or merely been exposed to a communicable disease, or suffered a slight, abortive, or ambulant attack of which they are ignorant, and the discovery of the usual portals of entry into the body of pathogenic microorganisms.

Infectious diseases prevail in two more or less distinct, but at times interwoven ways, which we speak of as the sporadic and the epidemic. The former represents the ordinary manner of spread, the latter the occasional or periodic explosive outbreak or wave, such as has been experienced recently with the pandemics of poliomyelitis, influenza and lethargic encephalitis.

What has been sought in the past and is being assiduously looked for in the present is an adequate explanation of the transition from the sporadic to the epidemic type of disease. We possess already quite accurate numerical data which show the manner in which epidemics begin, how they reach their maximum or peak, and then how they fall away again. Indeed, we now construct easily and recognize readily the epidemic curves of different epidemic diseases. But it is to be hoped that a new era is appearing in the study of epidemiology in which experiment may play a part along with observation, statistical and other. Already beginnings are being made in the attempt to define the distinction between the potentially fluctuating grades or power of infectivity and degree of virulence, taking the former to mean the natural propensity which a microbe displays in penetrating the ordinary portals leading into the body and its ability to survive and multiply there, and the latter the capacity to overcome the natural defenses when artificially inoculated. This is a field clearly approachable by experiment, using

small laboratory animals, among which arise from time to time, and much as happens with man himself, destructive epidemics induced by known microbes. Finally, there is the field in which not a single species of microbe is concerned but more than one, the first preparing, the other utilizing the prepared way for its more vicious purposes. Frequent examples of the last condition are observed among the lower animals, in which, of course, the opportunities for study are superior to those existing in man; but recent experiences in this and other countries during the influenza epidemic carry conviction of this relationship, since the original disease is recognized to be not of severe nature, while the pneumonia engrafted upon it is admittedly of highly fatal character.

My purpose in reviewing some of the notable events and tendencies in bacteriology which have come to light in the past twenty-five years has been to present to your consideration the achievements in one branch of modern medicine, and to indicate the relation subsisting between medicine and the more fundamental sciences of physics, chemistry and biology. Bacteriology has depended also for its development on its sister sciences of physiology, pharmacology and pathology, without which many of its phenomena could not be interpreted. It seems but proper to state that what has been attempted here for bacteriology could readily be equalled or even exceeded by spokesmen for those sister sciences, so surely has medicine grown scientific in recent times.

Simon Flexner

SCIENTIFIC EVENTS

MUSEUM OF THE BUFFALO SOCIETY OF NATURAL SCIENCES[1]

On October 16 the Buffalo Society of Natural Sciences opened its New Museum at 1231 Elmwood Avenue. This building is merely the inner court of a much larger museum which is to be erected by the society as soon as funds are available. The court measures approximately a fifty-five foot square. There is also a lobby, hall and office on the main floor and an office and two work shops on the second floor.

The entire idea of the New Museum exhibit is to give every man, woman and child who visits it the opportunity to understand the evolution of this earth from the time it was a part of a nebula arm up to the present decade. The hall of the building is devoted to astronomy and meteorology, many of the transparencies having just been obtained from the Mount Wilson and Yerkes Observatories.

The next exhibit is dynamical in nature, telling of what elements our earth is made and of the forces that have changed the earth's crust to form continents, oceans, rivers, lakes and mountains.

This is followed by an exhibit of paleontology which touches on the flora and fauna of the sixteen great geologic ages and ends with an evolutionary exhibit of man and one of the horse.

The last exhibit exemplifies the way in which man has utilized nature's products. It is truly marvelous how dyes have been made from coal tar; silk garments, alcohol, linoleum, tar and paper from wood; and the beautiful Deldare semi-porcelain ware from the commonest clay.

Among other interesting objects to be found in the museum are the relief maps of such localities as Mount Shasta, Mount Vesuvius, and the Grand Canyon of the Colorado. There is a very large relief map of Erie County which occupies a large space in the center of the floor. It was constructed by Frederick Burgie, of Rochester.

Two cases have been reserved as a display ground for especially beautiful objects owned by the society. At present these cases are filled with precious and semi-precious stones, many of them in the matrix.

Of especial interest to the children is the fine exhibit of birds and animals which have been mounted by Joseph Santens. Mr. Santens is at present completing a collection of native birds which will be studied by the school children under the new Nature Study Syllabus as published by the regents of the state of New York.

[1] From *The Museums Journal.*

MEDALS OF THE ROYAL SOCIETY

AT the anniversary meeting of the Royal Society on November 30 the medals were awarded in accordance with the announcement already made. The citations of several of the medalists were as follows:

The Rumford medal is awarded to Lord Rayleigh, who is distinguished for his researches into the properties of gases at high vacua, and whose work has opened the way to many valuable investigations. Some years ago Lord Rayleigh made a number of interesting observations on the afterglow in various gases noticeable after the cessation of an electric discharge, and these led in 1911 to his Bakerian lecture on "The Afterglow of Nitrogen." The investigation thus started has proved the subject of much of his recent work, and in a series of most valuable papers he has studied the properties of the gas in which this afterglow is visible.

A Royal medal is awarded to Dr. William Bateson, who is universally recognized as a leading authority on genetics, and has done more than anyone else to put that branch of inquiry on a scientific basis. The work that stands to his name is, however, but a fraction of that which he has inspired wherever biological research is prosecuted. In conjunction with Professor Punnett he worked out in detail one of the earliest cases of sex-linked inheritance. Peculiar association of genetic factors in gameto-genesis had previously been discovered by the same authors and described under the terms "coupling" and "repulsion." In 1911 they published two papers which proved that these phenomena are part of a more general phenomenon of linkage, the orderly nature of which was pointed out. Since these papers appeared the phenomenon has been shown by various workers to be widespread in both animals and plants. Three papers by Bateson and C. Pellew record a discovery of high interest and importance, viz., that the germ-cells of the same plant may vary in their genetic properties. It is further pointed out that the variation proceeds in an orderly way from the base of the plant to the apex. The conception is a novel one, and is bound to have great influence on the development of genetical theory.

The Darwin medal is awarded to Professor Roland Harry Biffen, who has worked out the inheritance of practically all the obvious characters of wheat and barley. Perhaps his best-known work is that on the inheritance of strength in wheat and on the inheritance of susceptibility and resistance to yellow rust in wheat. Biffen's activity is not by any means to be measured by his published work. Two of his new wheats—Little Joss, which owes its value to its immunity from rust, and Yeoman, which combines high yield with first-class baking quality—are among the most popular wheats in the country, and together account for something like a third, or even a half, of the wheat crop of England.

The Hughes medal is awarded to Professor Owen Williams Richardson for his researches on the passage of electricity through gases, and especially for those relating to the emission of electrons from hot bodies—a subject which Professor Richardson has made his own and christened "thermionics." The subject is of great industrial as well as of scientific importance.

THE PHILADELPHIA ACADEMY OF NATURAL SCIENCES

AT the annual meeting of The Academy of Natural Sciences of Philadelphia, held December 21, 1920, the following officers, councillors and members of the committee on accounts were elected to serve during 1921.

President: John Cadwalader, LL.D.
Vice-Presidents: Edwin G. Conklin, Ph.D.; Henry Skinner, M.D.
Recording Secretary: James A. G. Rehn.
Corresponding Secretary: J. Percy Moore, Ph.D.
Treasurer: George Vaux, Jr.
Librarian: Edward J. Nolan, M.D.
Curators: Witmer Stone, A.M., Sc.D.; Henry A. Pilsbry, Sc.D.; Henry Tucker, M.D.; Spencer Trotter, M.D.
Councillors to Serve Three Years: Charles B. Penrose, M.D.; Charles Morris; William E. Hughes, M.D.; Roswell C. Williams, Jr.
Councillor to Fill an Unexpired Term—1921 to 1922: Milton J. Greenman, M.D.
Committee on Accounts: Charles Morris; Samuel N. Rhodes; John G. Rothermel; Thomas S. Stewart, M.D.; Walter Horstmann.

At the meeting of the academy held November 16, 1920, the following was adopted:

Resolved: That in recognition of the exceptionally long period (covering 58 years) of his service to the academy, of his undeviating loyalty to its interests, and of the geniality of manner that endeared him to members and visitors alike, Dr. Edward J. Nolan be, upon the election of his suc-

cessor, given the honorary title for life of recording secretary emeritus, and that he be so designated in all official lists of the officers of the academy.

THE NEW YORK ACADEMY OF SCIENCES

The annual meeting of the academy for the election of officers, fellows and honorary members, the presentation of reports and the transaction of other business was held at the Delta Kappa Epsilon Club, 30 West 44th Street, on the evening of Monday, December 20.

The report of the corresponding secretary showed that there are now upon the rolls of the Academy 31 Honorary Members and 102 Corresponding Members. The death of the following Honorary and Corresponding Members was recorded with regret:

Sir Norman Lockyer, honorary member since 1880.
Professor Wilhelm Pfeffer, honorary member since 1898.
Professor Wilhelm Wundt, honorary member since 1904.
Professor George Macloskie, corresponding member since 1876.
Professor Joseph Paxon Iddings, corresponding member since 1896.

There have been held during the year 7 business meetings and 26 sectional meetings at which 40 stated papers were presented. The membership of the academy is 575, which includes 415 active members, 24 associate members, 109 life members, 8 patrons, 1 benefactor and 18 non-resident members, of whom 148 are fellows.

Record was made of the loss by death of 15 members.

The treasurer reported that the receipts for the fiscal year were $7,962.86, and the expenditures were $7,386.98. The investments of the academy amount to $53,198.88, held to cover the various funds. The details of the treasurer's report will be published in the *Annals*.

The academy elected Baron Gerard De Geer of Stockholm, Sweden, an Honorary Member. Fifteen members of the academy were elected to fellowship.

The following officers for 1921 were elected:

President: Edward L. Thorndike.
Vice-Presidents: William J. Gies, Charles L. Bristol, James F. Kemp, Robert S. Woodworth.
Recording Secretary: Ralph W. Tower.
Corresponding Secretary: Henry E. Crampton.
Treasurer: John Tatlock.

SCIENTIFIC NOTES AND NEWS

There is printed in the present issue of Science the presidential address before the American Association for the Advancement of Science given this week by Dr. Simon Flexner. We hope to print next week an account of the meeting and that the succeeding issues of Science will contain the official addresses given at Chicago and accounts of the meetings of the sections and of the affiliated societies.

Dr. William W. Coblentz, of the Bureau of Standards, has been awarded the Janssen Medal of the Paris Academy of Sciences for his work on measuring the heat of the stars.

During the past month Dr. Franz Boas, professor of anthropology at Columbia University, has been elected an honorary member of the Société des Amèricanistes of Paris and of the Folklore Society of London. He has also been elected corresponding member of the Prussian Academy of Sciences, Berlin, and has received the gold medal of the Anthropological Society of Berlin.

Dr. Ralph S. Lillie has resigned the professorship of biology at Clark University to accept the position of biologist, department of pure science, Nela Research Laboratories, National Lamp Works of the General Electric Company, Nela Park, Cleveland, Ohio. Dr. Lillie will retain his connection with the Marine Biological Laboratory, Woods Hole, and will carry on his work there in the summers as usual.

Paul M. Rea, president of The American Association of Museums, who has now become director of the new Cleveland Museum of Natural History, will be succeeded by Miss Laura M. Bragg in the directorship of The Charleston Museum, South Carolina.

DR. FRANK H. REITER, instructor in psychology at the University of Pennsylvania for the past six years, has resigned his position to become psychologist in the public school system of Newark, New Jersey, where he will succeed Dr. Francis N. Maxfield, recently appointed director of psychology in the Pennsylvania State Department of Education.

DR. WELLINGTON D. JONES, assistant professor of geography and dean in the college of science at the University of Chicago, recently sailed for England on his way to India, where he expects to make geographical studies.

DR. ALEŠ HRDLIČKA has been named doctor *honoris causæ* of the University of Prague.

PROFESSOR J. PERRIN (Paris) and Professor C. Fabry (Marseilles) have been elected honorary members of the Royal Institution, London.

DR. JOHN G. COULTER, who was in charge of the agricultural operations of the American Expeditionary Forces, and, after the armistice, Commandant of the Detachment for Agricultural Education, is now at Chateau Sandricourt, Meru, Oise, as manager of certain American-owned agricultural properties. He is collecting material concerning science teaching in France and would be glad to be of service to American enquirers for French educational data.

DR. RALPH E. HALL, formerly of the Geophysical Laboratory of the Carnegie Institution of Washington, has resigned from the Firestone Rubber Company, of Akron, Ohio, to accept a position with the Koppers Company, manufacturers of by-product coke ovens, at Pittsburgh, Pennsylvania.

F. L. RANSOME, of the U. S. Geological Survey, has left Washington for field work in Arizona.

YALE UNIVERSITY has received a letter from Charles Edward Adams, the head of the Hector Observatory at Wellington, New Zealand, accepting the appointment of associate in astronomy. Dr. Adams, who is the government astronomer and seismologist of New Zealand, has agreed to cooperate with the Yale Observatory in connection with photographing the stars of the southern hemisphere for compiling zone catalogues.

A JAPANESE translation of "The Subconscious," a textbook by Professor Joseph Jastrow, of the department of psychology of the University of Wisconsin, is to be published in the near future. The translation is being made under the direction of Dr. Nakamura, Japanese psychologist and editor of the Japanese *Journal of Abnormal Psychology*. The book was translated into French shortly after its appearance. A German translation was arranged for before the war but this undertaking has not been completed.

THE staff of the Lowell Observatory at Flagstaff, Arizona, at the request of Mrs. Lowell, widow of the late Dr. Percival Lowell, is giving a series of six lectures called "The Lowell Popular Lectures in Astronomy" in the large auditorium of the Northern Arizona Normal School. These lectures are free to the students of the school and to the townspeople in general. Dr. Hamilton gave the first lecture, "The Solar System," on December 14. The next lecture of the series will be given on January 5 by Mr. Truman on the subject "Curiosities among the Stars."

THE lectures for 1920–21 on the Silliman Foundation at Yale University were delivered by Professor Leo F. Rettger, on December 13 and 15. The subject was "Some problems of intestinal bacteriology."

DR. HIDEYO NOGUCHI, of the Rockefeller Institute for Medical Research, New York City, gave a lecture at the National Museum on November 17, on "Recent studies of yellow fever." The lecture was given under the auspices of the Army Medical School.

DR. L. EMMETT HOLT, of Columbia University, New York City, has been appointed Lane Medical Lecturer for the year 1921 at the Medical School of Stanford University, San Francisco, California. The lectures will be delivered in the week beginning on November 28, 1921, and the general subject will be "Growth and Nutrition."

Sir William Abney, distinguished for his contributions to photography and color vision, died on December 2 at the age of seventy-seven years.

The death is also announced of Dr. G. von Bunge, professor of physiology at the University of Basel, aged seventy-six years.

Dr. Karl Toldt, professor emeritus of anatomy at the University of Vienna, author of numerous publications on the development of the gastric and other glands and the embryology of the genital organs and on comparative anthropology, has died at the age of eighty years.

The Robert Koch Foundation for Combating Tuberculosis has awarded the prize of 5,000 Marks for the best work on the subject "The Value of the Various Kinds of Rays (Sun, Roentgen, Radium, Mesothorium) for the Diagnosis and Treatment of Tuberculosis" to Dr. Gassul, a former assistant in the Berlin University Institute for the Investigation of Cancer.

A formal resolution thanking Thomas E. Brittingham, of Madison, for the bronze bust of the late President Charles R. Van Hise, which he recently presented to the University of Wisconsin, has been voted by the Regents of the University. The resolution is as follows:

Resolved: That the Regents accept with their warmest thanks the "Pietro bust" of President Van Hise as a gift from the Honorable T. E. Brittingham. They recognize in this gift a continuation of that generosity which has already brought to the University the Lincoln statue and the Muir bust. Like these predecessors, this bust is a permanent possession for the University, of great historic interest and artistic excellence. It brings with it also those feelings which come with the likeness of a distinguished leader and beloved comrade whose recent loss is a fresh grief both to the regents and to the donor.

A meeting of the committee formed to establish a memorial to the late Sir Victor Horsley was held at the house of the Royal Society of Medicine on November 3; an executive committee was appointed to take steps to raise a fund, of which the senate of the University of London would be trustees, for the endowment of a lectureship or scholarship to perpetuate the memory of Sir Victor Horsley's scientific and public work.

UNIVERSITY AND EDUCATIONAL NEWS

Plans have been completed by the trustees of the Johns Hopkins Hospital for the reconstruction of the hospital group, which will involve an investment of approximately $11,500,000, including $6,750,000 as a permanent endowment fund. The first unit will be started next summer by the erection of a new pathologic building, costing $600,000, to replace the structure destroyed by fire last winter.

It is planned to establish a technical school at Oberlin College with accommodations for about 700 students.

The University of Liverpool has instituted a diploma in medical radiology and electrology. A course of post-graduate work extending over six months is required before a candidate can enter for the examination. Instruction in physics constitutes part of the course. Mr. C. Thurstan Holland has been appointed a university lecturer in charge of the department of radiology.

Dr. John Auer, of the Rockefeller Institute for Medical Research, has accepted the headship of the newly established department of pharmacology in the St. Louis University School of Medicine. The appointment of other members of the staff of this department will be announced later.

George Reber Wieland, Ph.D., lecturer of paleobotany in Yale University, has been appointed a research assistant in paleobotany with the rank of assistant professor.

Dr. Samuel W. Fernberger, assistant professor of psychology at Clark University, has become assistant professor of psychology in the University of Pennsylvania.

Dr. C. L. Turner, of Wooster College, has succeeded Dr. T. W. Galloway as professor of zoology at Beloit College.

DISCUSSION AND CORRESPONDENCE

HIGH TEMPERATURES AND EMISSION FROM GASES

IN view of the discussion between Dr. A. S. King[1] and Dr. G. A. Hemsalech[2] upon the origin of the spectra obtained in the carbon tube furnace, it may be of interest to call attention to the complete absence of emission lines in mercury vapor, argon, nitrogen and hydrogen, when heated to 3200° K. by means of a tungsten filament.

Observations of the heated zone adjacent to the filament while shielding the spectroscope slit from the filament radiation have shown no evidence of emission in the visible region from any of the above gases.

Professor F. A. Saunders was kind enough to photograph the spectrum from a tungsten spiral at 3200° K. operating in mercury vapor at approximately atmospheric pressure in a quartz bulb. He obtained no trace of emission lines, but did find an absorption at λ 2536.

The potential gradient along the wires varied from about 1.5 volt per centimeter in mercury vapor to 15 volts cm. in hydrogen.

These results suggest that the spectra obtained in the carbon tube furnace are neither primarily dependent upon potential gradient nor temperature, but are probably more of the nature of flame spectra produced by chemical reactions between the various elements present in the tube.

G. M. J. MACKAY

RESEARCH LABORATORY,
GENERAL ELECTRIC CO.,
SCHENECTADY, N. Y.

A POSSIBLE RELATION BETWEEN MECHANICAL, ELECTRICAL AND CHEMICAL QUANTITIES

TO THE EDITOR OF SCIENCE: In my note in your issue of November 26, page 509, on "A possible relation between mechanical, electrical and chemical quantities" (?), I regret that by an oversight I omitted to add that this relation applies to a valence of unity, as it is in the case of silver, which element was used in deducing it. For any other valence the atomic weight must of course be divided by that particular valence.

CARL HERING

PHILADELPHIA,
December 2, 1920

[1] *Astrophys. Journal*, 52, 187, October, 1920.
[2] *Phil. Mag.*, 36, 209, 281, 1920; 39, 241, 1920.

REQUEST FOR SEPARATES

IN a note from Professor A. Dehorne, of the Institute de Zoologie, Université de Lille, France, it is stated that the straitened financial circumstances of the university library at Lille permit the purchase of but few biological publications, *La Cellule*, for example, being the only cytological journal received. In accordance with Professor Dehorne's request, may I urge cytologists and other workers in biology to send him separates of their published articles, and thus contribute to the development of biology at Lille. Such contributions can easily be made, and they will surely be appreciated very highly.

LESTER W. SHARP

AN APPEAL FOR PUBLICATIONS FOR CZECHOSLOVAKIA

WITHIN the two brief years of its existence the new Czechoslovak Republic has established two new universities—one at Brno (Brünn) and the other at Bratislava (Pressburg), besides a series of high schools and several thousands of common schools. In addition, the University of Prague finds itself this year with a nearly redoubled number of students, of whom there are now over 10,000. With the generally and greatly reduced exchange value of European currency, it has become exceedingly difficult for the scientific men of these universities to provide themselves with literature published since 1914, and they appeal to their American colleagues for help in this direction. The publications needed are those reporting original research in all branches of science. Sets of reprints of individual investigators, and periodicals, will be particularly valued. Besides these, however, any reprints or scientifically valuable volumes that

can be spared will be welcome, even though they may be of the older dates. The publications should be sent to the Czechoslovak Legation, 1732 N St. N.W., Washington, D. C., from where they will be forwarded to the men and institutions most in need of them through the International Exchange Bureau of the Smithsonian Institution; or they may be sent or delivered to the writer.

A. Hrdlička

U. S. National Museum,
Washington, D. C.

NOTES ON METEOROLOGY AND CLIMATOLOGY

HURRICANES

We have been told by those who have visited the West Indies, that the natives have named the hurricane warning flag, which is displayed by the Weather Bureau, "*el panuelo del Diablo*," or the devil's handkerchief. Such a name conveys a fair impression of the natives' opinion of the hurricane. We are also told that the various hurricanes are named after saints of the church, and birth-dates, marriage-dates, and death-dates, are reckoned from them. In other words, the hurricane is decidedly an *event* in the lives of those who experienced it. But the native West Indian is not the only one who has a respectful regard for the hurricane, for the vessel masters, whose ships ply the Gulf of Mexico, and those residents of the United States who inhabit the cities along the Gulf Coast have learned by sad experience to betake themselves to places of safety upon the approach of these interesting and destructive storms.

The West Indian hurricane, or tropical cyclone, is an area of low barometric pressure; but it differs in several respects from the extratropical lows which cross the United States from west to east in unending procession. The isobars of the tropical cyclone are circular and the distribution of meteorological elements about the storm center is symmetrical, whereas the extratropical low usually is elliptical in form and displays a marked lack of symmetry in the distribution of temperature, precipitation and cloudiness. The tropical storm which affects the West Indies and the United States, usually has its origin in the doldrums, or low-pressure calms which in mild-, and late-, summer lie along latitude about 10° N., in the region of the Caribbean Sea and eastward. Its course is first toward the northwest, or west-northwest, and later, usually in about latitude 30° N., curves northward and finally northeast. After entering the mainland the effect of the storm is soon lost; and, while it may be very destructive in the immediate vicinity of the coast, its further progress is characterized by a diminution of intensity and an acquisition of the characteristics of the extratropical low.

One of the most troublesome features of the hurricane, from the meteorologist's point of view, is that the main part of its course lies over water, and, since ships make every effort to escape the storm, the forecaster is left in utter darkness as to the exact location of the disturbance and its direction of movement. When a warning is once given of the presence of such a storm in the Gulf, all vessels in port refrain from sailing until the danger is passed. While this is decidedly profitable for the vessels, it makes the meteorologist the victim of his own efficiency, for it deprives him of observations of clouds, pressure, etc., which are so valuable to him in forecasting the part of the coast where the hurricane is most likely to strike. For this reason, it is necessary to utilize whatever observational data can be obtained along the coast, and Dr. Cline, of the New Orleans office of the Weather Bureau, has recently published a paper[1] in which he states his belief that the tides are a reliable criterion of the direction of motion of the hurricane while a considerable distance at sea.

Dr. Cline, after a brief mention of the wave-producing powers of winds, takes up all the hurricanes which occurred between 1900 and 1919. In their chronological order, he

1 Cline, Isaac M., "Relation of Changes in Storm Tides on the Coast of the Gulf of Mexico to the Center and Movement of Hurricanes," *Monthly Weather Review*, March, 1920, pp. 127–146.

points out the relations existing between the tides at various Gulf stations and the position of the hurricanes in the Gulf. He is enabled by these studies to show the portion of the storm in which the greatet wave-producing winds occur. The quotation from John Eliot's "Cyclonic Storms in the Bay of Bengal" regarding the wave-producing power of the hurricanes is worth repeating here:

> Whatever explanation be adopted of the production of these large waves, there is no doubt of the general principle that air moving over a water surface always produces waves, and that the magnitude of the waves is dependent upon the extent of the water area over which they blow and upon the force of the winds. It is evident that the strength of the swell or the distance at which it will be sensibly felt in the open sea, will depend partly upon the strength of the producing winds and partly upon the distance over which the producing winds act with no considerable change in direction. The rapid movement of the air over the surface of the sea gives rise, by some species of cumulative action to a continuous succession of large parallel waves so long as the winds are fairly steady in character. Waves that are produced in this manner travel steadily onward in the same general direction so long as they meet no obstruction, and if they pass beyond the area of strong winds, they decrease slowly in height and force.

It was noted by Mr. Eliot that in the Bay of Bengal the swells were observed 400 miles from the center of the storm and forty-eight hours before its arrival.

Dr. Cline has given a diagram of the type of waves and swells which emanate from a hurricane, and he finds that the greatest waves are produced in the rear right-hand quadrant of the storm and travel forward through the storm and make themselves felt far in front and mostly to the right side of the line of advance at the time the wave left the storm. These waves travel in the direction of the storm's motion. Waves of lesser amplitude are sent out to the right and left of the center of advance of the storm in the front half, still smaller, weaker waves are sent out to right and left in the rear of the storm; and finally, the weakest waves of all are sent out in the rear.

How intense the winds are in the rear right-hand quadrant of the advancing hurrricane may be seen from the following (indicated) wind velocities observed at Burrwood, La., near the mouth of the Mississippi River, upon the occasion of the hurricane of September 29, 1915:

> Sixty miles per hour or above prevailed for a period of 13 hours.
>
> Seventy miles per hour or above prevailed for a period of 12 hours.
>
> Eighty miles per hour or above prevailed for a period of 11 hours.
>
> Ninety miles per hour or above prevailed for a period of 3 hours.
>
> One hundred and eight miles per hour prevailed for a period of 2 hours.
>
> One hundred and sixteen miles per hour prevailed for one third of an hour.
>
> There was a gust with 1 mile at the rate of 140 miles per hour.

It appears that as these waves begin to reach the coast there is a piling up of water, which is, of course, in excess of the normal predicted tide. By carefully noting and comparing the high water at various stations it is possible, Dr. Cline believes, to detect changes in direction of movement of the disturbance. As an example of this, and also of the fact that the rise of water precedes any change in the barometer, he cites the case of the storm of September 11–14, 1919, in which the "barometer at Burrwood, New Orleans, Galveston and Corpus Christi was either stationary or falling only a few hundredths of an inch, the water, first at Burrwood, later at Galveston, and then at Aransas Pass was rising in feet, telling the story of the movement and of the change in the course of the storm as plainly as could be told."

By this method it is possible to tell whether the storm is shifting its course to right or left by the shifting of the point of greatest rise to right or left. The regular tides are not obscured by these storm tides except perhaps in the last twelve hours before the storm strikes, when there are other features of prognostic value which can be relied upon. The

highest water occurs a few miles to the right and at about the time of passage of the center and high water is observed from 100 to 200 miles to the right of the storm, while to the left it is hardly observed at all.

An interesting point is the effect upon the height of the water which may be attributed to the decreased atmospheric pressure in the center of the storm. This of course will allow the water to be raised in that vicinity. In the great hurricane of 1900, which passed inland at Galveston the pressure was low enough to have caused a rise of 1.5 feet in the level of the water. There is no danger of confusing such an effect as this, however, with the main storm-tide, because the amplitude of the storm-tide is much greater; indeed, in this case, it was 15 feet.

The apparent simplicity of this method of forecasting hurricanes must not be overestimated, however. The hurricane is a capricious disturbance and difficulties may be introduced by its unusual conduct either with respect to its rate of movement, or point of recurving. An example of this may be made in the hurricane of September 21–22, 1920.[2] This storm, as indicated by the tides after it entered the Gulf, was moving in the direction of the coast between Corpus Christi and Galveston; but it recurved and with unexpected speed swept northward and inland near Morgan City, La. The difficulty was that, owing to the unexpected late recurving and unusual speed, it was impossible to forecast the actual point of entrance. As a consequence, the warnings were displayed first from Corpus Christi to Port Arthur, Texas, and then extended to include the coast as far east as Pensacola. In retrospect, it is seen that the method worked out well enough; but the peculiarities of the storm's movement preclude a satisfactory application of the method. In this case, the method did not give as great precision as might be required; but it must not be inferred that the method is faulty. Anything that will improve the forecasting of hurricanes is welcomed, and it can not be said that Dr. Cline's paper does not constitute a genuine contribution to this difficult and troublesome question.

C. LeRoy Meisinger

Washington, D. C.

[2] *Cf.* Cline, Isaac M., "The Life History of Tropical Storm in Louisiana, September 21 and 22, 1920," *Monthly Weather Review*, September, 1920, pp. 520–524.

SPECIAL ARTICLES

THE COLLECTION OF RADIUM EMANATION FOR THERAPEUTIC USE[1]

The practise of using radium emanation instead of radium salts for therapeutic purposes is now thoroughly established in this country. Its advantages are so patent that all of the hospitals and clinics, where large quantities of radium are employed, have had their radium salts converted to soluble form, and collect emanation from solution.

It is necessary, however, to separate the emanation from hydrogen, oxygen and other gases which accompany it in the collection, in order to reduce its volume to meet the requirements. This can be accomplished by several different methods: (1) The chemical method of purification by heating copper oxide and other chemicals in a tube through which the gases pass before being confined in small volume over mercury; (2) the method of Professor Duane[2] of passing the gases over an electrically heated partially oxidized copper wire; (3) the method of freezing emanation at liquid air temperature and pumping off the residual gases. This method may also be employed in conjunction with either of the first two.

All three methods require a rather complicated apparatus and manipulations which can be carried out only by a specialist. It occurred to the writer that some simplification might be introduced by collecting emanation from the highly heated or fused radium salts, thus avoiding the presence of water and the consequent large volume of hydrogen and oxygen resulting from its decomposition. It

[1] Published with permission of the director of the United States Bureau of Mines.

[2] *Phys. Rev.* (2), 5, 311, 1915.

is probable that the gas collected from the fusion or high-temperature treatment would require no further purification for therapeutic use.

The liberation of small quantities of emanation by high temperatures has already been successfully applied in the quantitative measurement of radium by the emanation method. There is nothing novel in the idea, and its application has already been tested out under somewhat different conditions. The object of the present note is simply to call attemtion to the possibility of applying the same principle to the collection of large quantities of emanation for therapeutic use, and to leave the field open for experimentation by the different laboratories and companies interested.

The procedure might be varied in several ways. Fusion might be employed with or without a flux; possibly temperatures considerably below fusion will be found to liberate emanation from some salts with a satisfactory recovery. The salts come mainly in consideration are: The chloride, bromide, carbonate and sulfate. With the chloride or bromide the corresponding lithium salt might prove to be a good flux. Experiments with other salts of radium might disclose one that would yield its emanation at a still lower temperature.

It should also be investigated whether the state of fusion per se is favorable to the liberation of emanation. It is possible that a viscous fusion just above its melting-point would not liberate emanation so readily as the more porus salt before fusion. The effect of various proportions of barium should also be studied, as well as volatilization losses under various conditions with different salts.

The heating should preferably be electrical, but whether internally or externaly applied is a matter for determination.

The collection after liberation might be by means of mercury displacement or by liquid air condensation.

S. C. LIND

GOLDEN, COLORADO,
November, 1920

A QUANTITATIVE SURVEY OF THE FLORA OF LAKE MENDOTA

IN the summer of 1919, quantitative determinations were undertaken for the Wisconsin Geological and Natural History Survey, of the submerged vegetation of Lake Mendota, Madison, Wis. The object of the work was to form an estimate of the total amounts of the various species present in the lake, and to obtain such additional data as might be available on their comparative distribution.

The plants were gathered by hand from measured areas of the lake bottom. For this purpose the whole plant zone of the lake was divided into stations according to local differences in physical and floral characteristics. Samples were gathered at different depths in each station. The plant zone is continuous around the lake in water not deeper than 7 m. The samples thus gathered were separated into their component species, and their wet and dry weights determined.

For purposes of calculation the plant zone was divided into three depth-zones, namely, 0 to 1 m., 1 m. to 3 m., 3 m. to 7 m., this arbitrary classification being based on evident differences in the character of the vegetation at different depths. By averaging the weights of the various samples gathered within one depth-zone, and comparing this average with the total area of that zone, as measured on a map, the total weight of each species in each zone was computed, and by addition the total weights for the whole plant zone.

The total amount of plants collected in this way was some 93 kilograms wet, 11 kilograms dry, the average water content being about 88 per cent. This material was obtained in 221 samples taken from 35 stations. The yield of the entire lake, estimated on the basis of these collections, is in round numbers 18,500,000 kilograms wet, 2,100,000 kilograms dry. The total area of the plant zone is 10,040,000 square meters. The yield per unit area is therefore 18,426 kilograms per hectare wet, 2,091 kiligrams per hectare dry (or 16,215 pounds per acre wet, 1,840 pounds per acre dry).

Almost one half of the total yield is found in water from 1 m. to 3 m. in depth. More than one quarter is found in water shallower than this, and a quarter in deeper water (3 m. to 7 m.).

Almost one half of the wet weight of the total yield is made up of *Vallisneria spiralis*. The dry weight of this plant forms a somewhat smaller fraction of the whole, owing to its relatively high water content. The remainder of the vegetation is composed mainly of various species of *Potamogeton*. *P. amplifolius* composes about one quarter of the total, *P. pectinatus* and *P. Richardsonii* each about one tenth. None of the remaining species exceeds 4 per cent. of the total.

The above is an average for the whole plant zone. At different depths the situation varies. *Potamogeton pectinatus, P. Richardsonii,* and other species, including *Najas flexilis, Ranunculus aquatilis,* and *Chara crispa,* bulk large in water less than 1 m. in depth. Between the depths of 1 m. and 3 m., *Potamogeton amplifolius* replaces to a large extent the other species of this genus, and *Myriophyllum* and *Ceratophyllum* are abundant. In the deepest water (3 m. to 7 m.), *P. amplifolius* composes about one half of the entire vegetation. *Vallisneria* forms a large part of the growth at all depths.

The greater the depth, the smaller is the number of species. Many plants are restricted to the shallow water. Among these are *Ranunculus* and the rare species *Potamogeton lucens.* On the other hand, most of the *Potamogeton zosterifolius* is found in water deeper than 3 m., and about three quarters of the *Myriophyllum* and *Ceratophyllum* is found in water from 1 m. to 3 m.

Within each depth-zone, the abundance of the vegetation is different in different stations. The figures obtained represent, therefore, averages of widely varying conditions. Much of this difference is correlated with the character of the lake bottom. Especially in the shallowest water, there are large tracts of sandy bottom, on which *Potamogeton pectinatus, P. Richardsonii, Ranunculus, Najas,* and *Chara* thrive, while other species do better in muddy regions. *Vallisneria* flourishes equally on mud or on sand. Both the character of the bottom and the nature of the flora are more uniform in the deeper water.

In addition to the plant zone as a whole, there are a large number of shallow bays which have distinctive flora. Here grow a number of marsh and pond plants not found elsewhere in the lake, including *Scirpus lacustris, Castalia odorata, Nymphaea advena, Typha latifolia,* and other less common species Almost all the other species found in the lake are also present in the shallow bays. Here also the character of the vegetation varies considerably with the nature of the bottom. Quantitative determinations of this class of cases were very difficult to make, owing to the irregular, patchy nature of the growth, especially in the case of the larger marsh plants.

Around the margin of the lake extends a narrow strip of *Cladophora glomerata,* growing attached to rocks of various sizes. This plant varies greatly at different points in the density of its growth. Samples were collected from representative spots, field notes taken on the general distribution and abundance of the species, and an estimate of the total made on the basis of these data.

A detailed report of these investigations is to be published in the *Transactions* of the Wisconsin Academy of Sciences, Arts, and Letters.

H. W. Rickett

Department of Botany,
University of Wisconsin

THE AMERICAN CHEMICAL SOCIETY

(*Continued*)

DIVISION OF DYE CHEMISTRY

A. B. Davis, *chairman.*

R. Norris Shreve, *secretary.*

Wednesday and Thursday

Physiology Lecture Room

New naphthalene dyes: A. S. Wheeler. The tones produced vary with the reaction of the bath and also may be modified considerably by the use of mordants. The sulfonation of napthalene with fuming sulphuric acid, is carried out at a low temperature and is so regulated that the

naphthalene 1, 5-disulfonic acid is obtained. This is fused with caustic soda and the resulting naphthol is oxidized with chromic acid to juglone. This hydroxynaphthoquinone yields a wide variety of halogen derivatives; additional products at low temperatures, and substitution products at high temperature. These are dyes since they contain both the chromophore and auxochrome groups. Both chlorine and bromine derivatives of juglone have been prepared. Tribromojuglone is obtained in yields of nearly 100 per cent. of the theoretical, is rich red in color while its sodium salt is indigo blue. The new work in this field includes the preparation of some ethers. Methyl ether, brick red crystals, its sodium salt being difficult to prepare; ethyl ether, yellowish red needles, its sodium salt being readily made. The influence of the alkyl radicles is to cause the dyes to become reddish in tone.

Applications of maleic and fumaric acids and their salts in the textile industry: J. H. CARPENTER. This paper gives a brief outline of the excellent results obtained with the use of maleic and fumaric acids when used as mordanting assistants in the chroming of wool, and briefly points out the real commercial possibilities for these acids. The subject of their use in the scrooping and dyeing of silk is taken up and some positive results pointed out in that field. The uses of maleic acid in cotton printing are mentioned and the reasons why negative results were sometimes gotten are briefly enumerated. The application of these acids in dyeing various materials with special colors are discussed and the results gotten in using them for dyeing of leather are mentioned.

The anilides of beta oxy napthoic acid: E. R. BRUNSKILL. If instead of beta-oxy-napthoic acid, the anilide is used for dyeing by the ice process the colors produced are brighter in shade and much faster to washing. A comparison is made of beta-oxy-napthoic acid, the anilid, toluide and p-chloranilide, coupled with aniline, p-nitraniline, para-toluidine, meta-nitro-para-toluidine, para-chloraniline-o-sulfonic acid, and o-chlor-p-toluidine sulfonic acid.

The education of the research chemist: ROBERT E. ROSE, PH.D. The research men turned out by the educational system of this country are excellent—this has been shown by the way the dye chemists have succeeded. If fault can be found with the system, it is with its failure to train the senses systematically during childhood, and with the emphasis placed on memory courses and second-hand data. We shall have a higher average of research attainment when we appreciate the national importance of the grade school teacher and give the calling the dignity it merits. Our universities need to escape from "text-book" teaching and our research geniuses need to be freed from routine duties—though research is only the use of the results of accurate observation as material for logical reasoning; yet to produce those who can observe rightly and think clearly is the most difficult educational problem. The American Chemical Society might aid materially by organizing a section devoted to research training where teachers and technical men could exchange views.

Extraction of resorcinol from the alkali melt: HARRY MCCORMACK. The object of the investigation reported herewith was to determine some more economical method of separating resorcinol from aqueous sodium sulphate solution obtained from the neutralization of the alkali melt in which sodium resorcinate is produced, than the customary practise of extracting with ether, or with ether and benzene. The method worked out effects the separation of resorcinol from the sodium sulphate, sodium sulphite solution, by evaporating the solution to such concentration that practically all the sodium sulphate crystallized, leaving all of the resorcinol in solution. The resulting solution is evaporated to complete dryness, pulverized and the resorcinol extracted from the dry mass by treatment with ethyl alcohol or other suitable solvents for resorcinol in which sodium sulphate and sodium sulphite are insoluble. It is found that with a 72 per cent. alcohol solution sodium sulphate is insoluble. Such an alcohol solution dissolves the resorcinol to the amount of more than 50 per cent. of the alcohol used and from this alcohol solution it is easy to secure the resorcinol by distilling off the alcohol and then purifying the resorcinol by vacuum distillation. Solvent loss amounts to 1½ to 2½ per cent. of the weight of the resorcinol.

Photosensitizing dyes: LOUIS E. WISE.

The preparation of lepidine and related bases: LOUIS A. MIKESKA. Recent developments in the field of photosensitizing dyes have brought lepidine and related bases again into prominence. A procedure is given for the preparation of lepidine, p-tolulepidine and p-ethoxylepidine.

Isocyanine dyes from lepidine and its homologs: ELLIOT Q. ADAMS and HERBERT L. HALLER. The

quaternary addition products of sufficiently pure lepidine (or homologs of lepidine) give when treated with alcoholic alkalis in hot, concentrated solution, dyes of the isocyanine type, similar to, but not identical with, those given by the corresponding derivatives of quinaldine. The preparation of 5 such dyes is described. The formation of isocyanines from lepidine confirms the hypothesis, now generally accepted, that these dyes contain two quinoline nuclei attached to a central carbon atom in positions 4 and 2, respectively.

Kryptocyanines: A new series of photosensitizing dyes: Elliot Q. Adams and Herbert ,L. Haller. A new type of photosensitizing dye having an absorption maximum near 7,000 Å. and a sensitization maximum near 7,400 Å. is described. These dyes are formed by the action of alcoholic alkali and formaldehyde (or chloroform) on the alkyl halides (or other quaternary addition compounds) of (sufficiently pure) lepidine and its homologs. Dyes of the same or similar type are produced under some circumstances in the absence of formaldehyde or chloroform. Tentative suggestions are made as to the structure of these dyes. The name "kryptocyanine" is suggested.

Synthesis of photosensitizing dyes (II.), dicyanine A.: L. A. Mikeska, H. L. Haller and E. Q. Adams. Directions are given for the preparation of 2, 4-dimethyl-6-ethoxyquinoline from p-phenetidine; for the preparation of the ethiodide of this base, and, from it, the nitrate and iodide of Dicyanine A.

Naphthalene sulphonic acids. III. An alternative method for the qualitative detection of naphthalene 2–7 and 1–6 disulphonic acids. J. A. Ambler. In naphthalene sulphonic acids. II. A method for the qualitative determination of some of the naphthalene sulphonic acids, by J. A. Ambler and E. T. Wherry, read at the meeting of the American Chemical Society at St. Louis in April, a method of detecting naphthalene 1–6 and 2–7 disulphonic acids by a microscopic examination of their β-naphthylamine salts, was given. It is also possible to detect these two acids in mixtures by the different solubility of their β-naphthylamine salts in 4 volumes of 95 per cent. alcohol and 1 volume of water, the 2–7 salt being more insoluble. The 1–6 acid is detected by converting to the sodium salts and subsequent treatment with sulphuric acid, in which the sodium salt of the 1–6 acid is more insoluble.

An investigation of the N. S. Passay of phosphoric acid and soluble phosphates: A. E. Stearn, H. V. Farr and N. P. Knowlton. The N. S. P. method is incapable of yielding true results except at one specific concentration, namely, 6.2 mg. per c.c. of P_2O_5 in sol. The error varies from about + 3 per cent. at a concentration of .62 mg. per c.c. to — 8 per cent. at a conc. of 10.9 mg. per c.c. This is probably due to the formation of acid phosphates of silver which are slightly soluble, the amount formed increasing rapidly as the phosphate concentration is increased and the excess of silver nitrate is simultaneously decreased. By modifying the method to the extent of transforming the acid to the tri-sodium salt results are obtained which coincide with the results yielded by the pyrophosphate method and are independent of the concentration.

The production of American storax from the red gum tree: S. A. Mahood.

Detection of some substituted sulphonic acids: D. F. J. Lynch. In the work on substituted sulphonic acids in this laboratory, the need of some quick method of detection and identification for such acids as 1-8 dinitro naphthalene 3-6 disulphonic acid, 1-8 diamino naphthalene 3-6 disulphonic acid, 1-amino 8 naphthol 3-6 disulphonic acid (H acid), and 1-8 dihydroxy naphthalene 3-6 disulphonic acid (chromotrope) was felt. Mixtures of these acids were encountered in our work on the nitration of 2-7 naphthalene disulphonic acid and the subsequent reduction and hydrolysis of the nitro compound formed. Each of these four acids can be identified in the presence of the other three by the formation of salts with organic bases.

Benzene disulphonic acid from benzene monosulphonic acid: C. E. Senseman. Barium benzene monosulphonate is treated with concentrated sulphuric acid at temperatures of 220°, 250° and 280°. The quantities of acid used range from 50 per cent. excess to 700 per cent. excess. The duration of the various experiments is from 8 to 10 hours. The progress of the reaction is determined in each case by removing a sample at the end of each hour and analyzing for the disulphonic acid. Vanadium pentoxide and sodium sulphate are tried out as catalysts. In some cases an increased yield of 20 per cent. results.

Qualifications of organic chemists: M. L. Crossley. Uniformity of action by men who employ chemists in passing upon their qualifications is

especially needed. In addition to the training which a man receives fitting him as a chemist, he should also have a definite amount of experience before he is considered a chemist to qualify as such and should have a university training or its equivalent in the fundamentals of chemistry, physics and mathematics, and in addition, have had at least five years experience in a research laboratory connected either with the university or an industry. This can best be accomplished by appointing men who have just been graduated as junior chemists to be advanced to assistant chemist after two years of satisfactory work under the direction of senior chemists. From the assistant grade appointment should be made as a chemist after satisfactory evidence has been given by assistant chemist of his ability to understand and appreciate the responsibility to his profession in rendering efficient and accurate service. The title of chemist should carry with it distinction and should not be lightly given to men whose qualifications do not fit them for the kind of service which the chemist should render to his profession.

Laboratory equipment: C. V. OGILVIE, G. S. SIMPSON, M. L. CROSSLEY. In order to secure accuracy and efficient results in analysis in organic research laboratories it is imperative that we use standard equipment in which the factor of equipment error is reduced to a minimum. We propose two such pieces of standard equipment for laboratory purposes, first, a diazotization burette. This is a jacketed burette which can be cooled to any desired temperature by circulating brine and which can be used for diazo solutions easily decomposed by light. The burette is similar to a condenser of the shellback type, having a blue line on a white background. The lower end of this burette should be made of capillary tubing so that only a small volume of solution is held in this portion of the burette. The burette is sealed in a condenser tubing, care being taken to avoid an exposure of much of the burette surface. The inlet and outlet tubes for circulating the brine solution through the jacket are so placed as to allow the water to surround the entire burette. It is protected from the direct rays of the light by standing the jacket leaving only sufficient exposed surface of the jacket to enable the operator to read the volume of the solution. The same thing can be accomplished by using a colored solution for cooling the jacket. Second, a standard stirring equipment for use with volatile liquids. We propose laboratory stirring equipment to be used for either the extraction or mixing of volatile liquids consisting of a wide mouth flask fitted with thermometer and glass stirrer driven by a shaft which extends through a condenser. This vertical shaft is driven from a 1″ horizontal shaft 36″ above the bench. The vertical shaft is supported from the wall by iron bearings and placed 7″ from the horizontal shaft. By proper adjustment of the driving pulleys, one can carry on stirring at different heights from the operating bench. The bearings are of glass and the pulleys of wood. The pulleys have three speeds and are driven by 1/8″ leather belting. This type of equipment does away with the necessity of mercury seal which is usually necessary in work of this kind and which frequently contaminates the reaction mass.

Action of sulfuric acid on nitro carbocylic compounds: M. L. CROSSLEY. Certain nitro compounds react with sulphuric acid under certain conditions with explosive violence producing aminophenol, sulfonic acids and complex compounds of unknown composition. The reaction is exothermic and is quite general. The temperature at which the reaction takes place is just a few degrees above that at which the substances remain in contact unchanged. It is the purpose of this paper to emphasize the dangerous character of this reaction, especially when the reaction mass is large and is confined in a vessel with a closed top. On a manufacturing scale it is extremely difficult to control this reaction and it should be guarded against in processes where it might be secondary to some main reaction. A few months ago this reaction was brought about by accident in a plant in this country and it resulted in a bad explosion in which several men were badly injured and one man killed. It is hoped that other manufacturers will profit by this experience and thus prevent loss of life and property which would otherwise result.

DIVISION OF INDUSTRIAL AND ENGINEERING CHEMISTRY

H. D. Batchelor, *chairman*

H. E. Howe, *secretary*

Cellulose Symposium. G. J. Esselen, Jr., *chairman*

Regenerating book-stock: CHARLES BASKERVILLE and CLARENCE M. JOYCE. Attention is directed to the enormous amounts of old magazines and books, much of which now goes to waste, although much is converted into box-board, roofing paper, etc. The term "bookstock" is applied in this communica-

tion to used paper made primarily from chemically prepared pulp. Conservation will result in reworking more paper wastes. The differential in value of the regenerated pulp which goes back to bookstock or into boxboard must bear the cost of "de-inking." To conserve the strength and length of fiber and secure the greatest yield, the paper requires mechanical treatment whereby the fibers are loosened and drawn apart with minimum tearing; the chemical treatment should lift the ink, the substances used dissolving or emulsifying the binder and carrying the pigment particles away in the necessary washing. A combination of borax, soap, kerosene and pine oil, does this best; the last mentioned being a natural solvent of rosin, used as size for many kinds of paper, and a solvent and emulsifying body for gums and resins, which are present in ground wood, used in cheaper grades of magazine papers. The process has been patented.

Recovering newsprint: Charles Baskerville and Reston Stevenson. With the prices obtaining, the recovery of old newspapers in such condition as to be used again for newsprint, offers an opportunity for relative conservation, if not distinct economy in fact. Methods previously devised for recovering printed papers made little or no distinction between newsprint stock and book stock. The former normally contains a large proportion of ground wood, which yellows on treatment with caustic soda, the usual basis of chemicals applied in de-inking printed paper stock. The authors, recognizing the difference in character of the fibers in the several kinds of stocks, have studied the fundamental principles involved and devised a novel method for completely de-inking newsprint stock containing a large percentage of ground wood with the minimum production of yellowing. The process developed depends upon the addition of American fuller's earth to the alkaline solution in which the printed or soiled newspapers are pulped. The binder is loosened and the ink lifted from the fibers, the oils being absorbed by and the ink particles adhering to the argillaceous earth, which is washed away from the fibers through a fine gauze screen. Temperature factors and concentrations are given. A finished pulp, free from pigment and binder, clean as when first made, has been obtained ready-made for the paper mill. If desired the stock may be bleached by treatment with dilute sulphurous acid, but this is unnecessary for ordinary newsprint stock.

On the cellulose content of various compound celluloses: Louis Kahlenberg. Using the ferric chloride hydrolysis method described at the Urbana meeting of the American Chemical Society, various compound celluloses were decomposed and their cellulose content estimated. The following materials were thus investigated: (1) Woods—bass wood, birch, black walnut, cherry, hemlock, maple, redwood, red oak, white ash, Washington fir, white pine, yellow pine; (2) Straws—wheat, oats, rye, barley, millet, soy beans, corn stalks, corn husks, timothy hay; (3) Nutshells—black walnut, English walnut, hickory, filbert, Brazil, pecan, almond, peanut, horse chestnut; (4) Barks—hemlock, pine. So far as comparable results have previously been presented in the literature by others, the values obtained are found to be, in general, of the same order of magnitude as those in this research.

The constitution of cellulose: Harold Hibbert.

The acid hydrolysis of sugar cane fiber and cotton seed hulls: E. C. Sherrard and G. W. Blanco. Sugar cane fiber and cotton seed hulls were hydrolyzed by digesting with dilute sulphuric acid under 115 to 120 pounds steam pressure. About 27 per cent. of total sugar was obtained from the bagasse and about 14 per cent. from the cotton seed hulls. Of the total sugar obtained from these materials very little was fermentable, the greater proportion being xylose. The yield of sugar from bagasse using Hudson and Harding's method was 21.22 per cent. of the original dry fiber. Of this 57 per cent. was obtained as crystalline xylose and shown to be identical with that from cotton seed hulls. Attention is called to the fact that pentose sugar influence the equilibrium established in the hydrolysis of cellulose of hexose sugars. When present in sufficient quantities they prevent the formation of fermentable sugars. It is pointed out that bagasse is a promising source of xylose or furfural.

Charles L. Parsons,
Secretary

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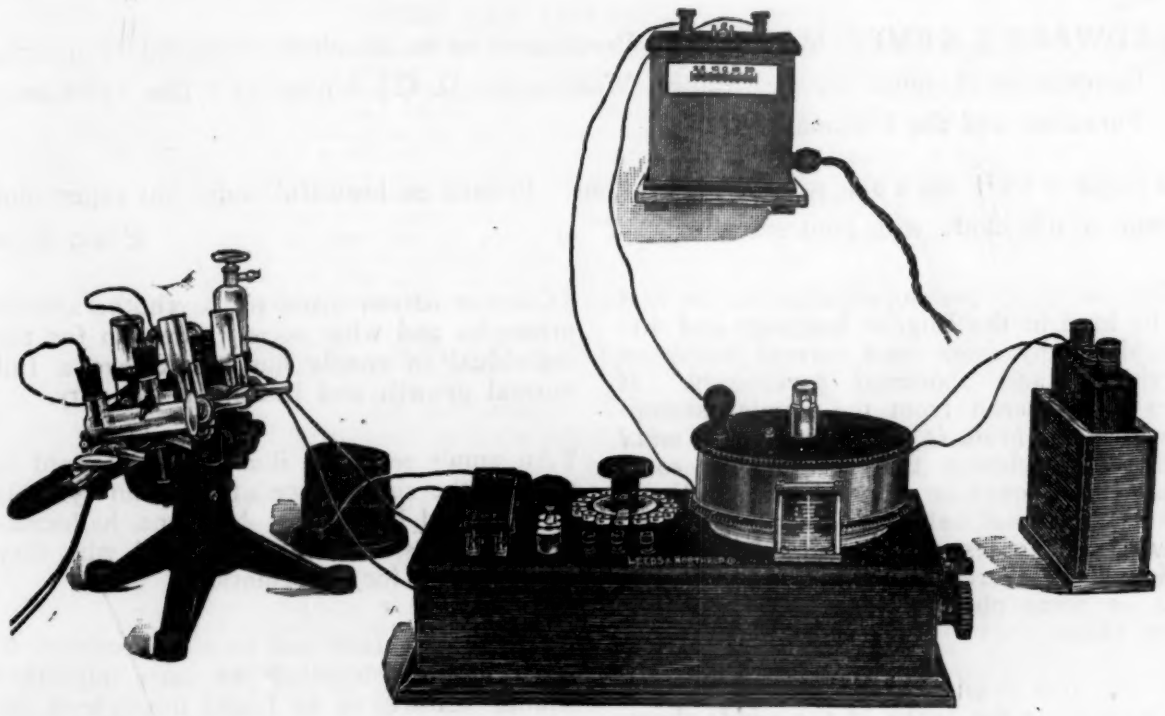

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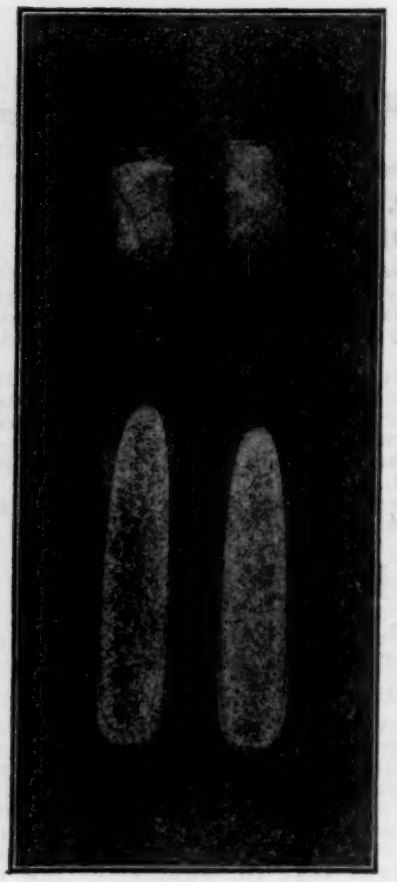

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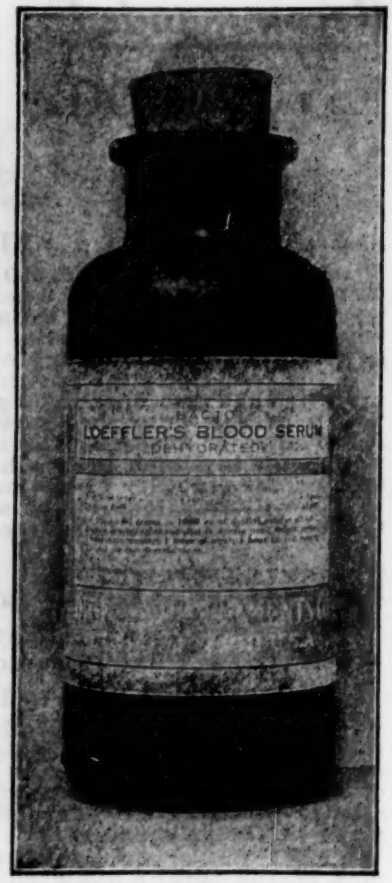

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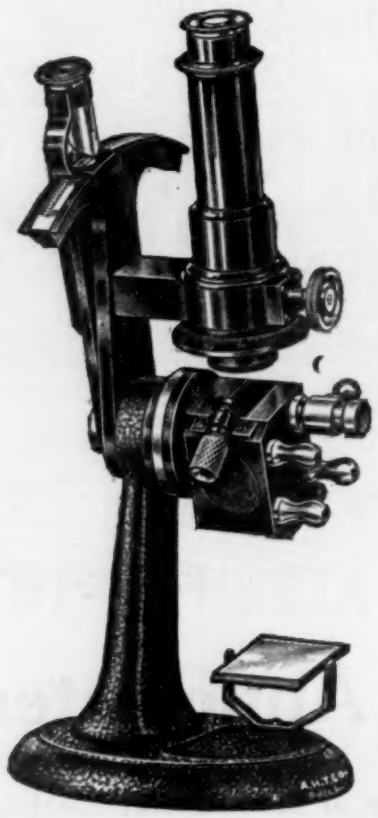

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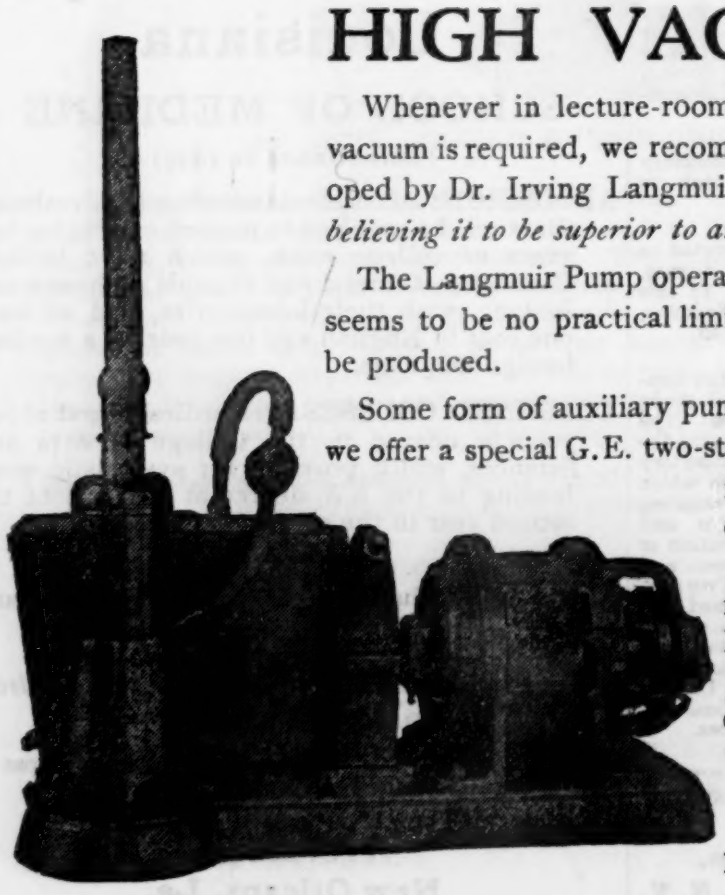

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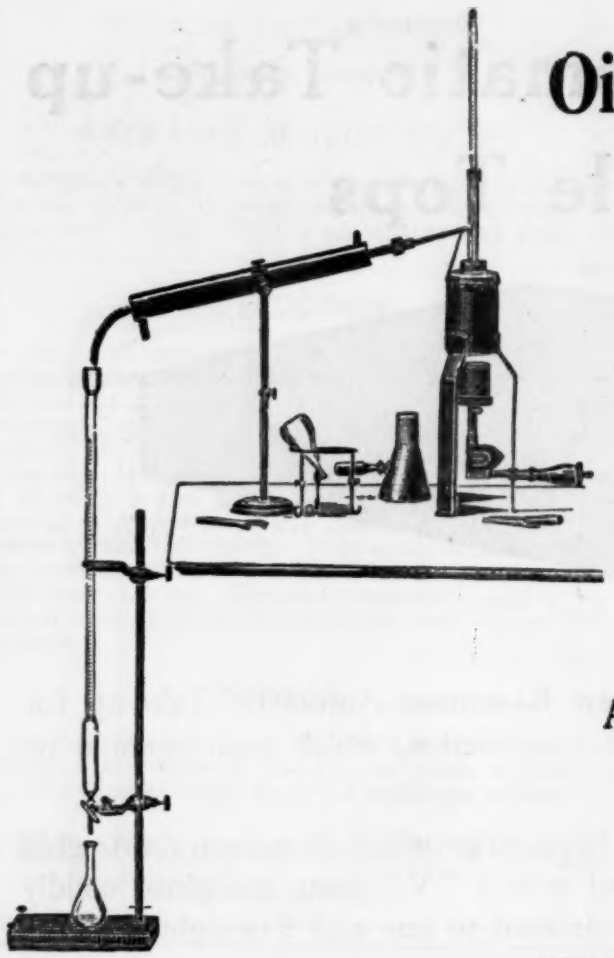

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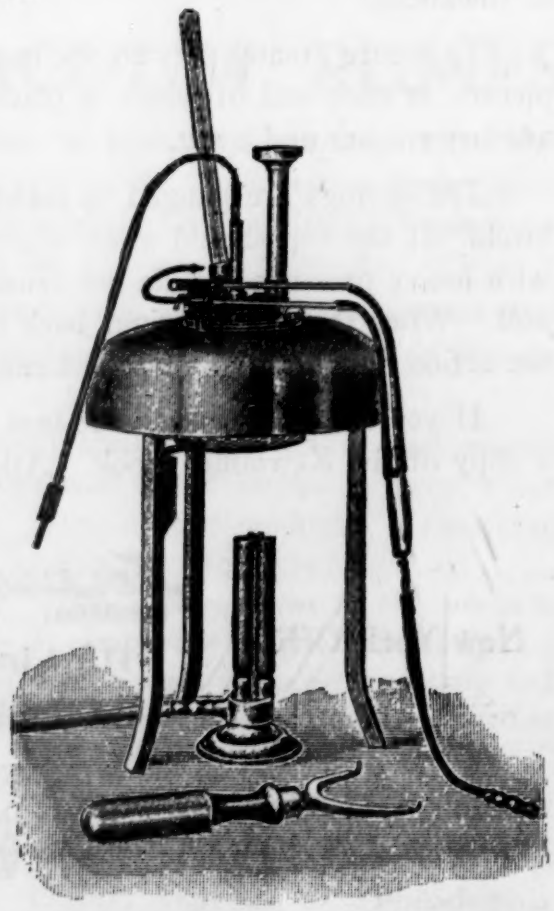

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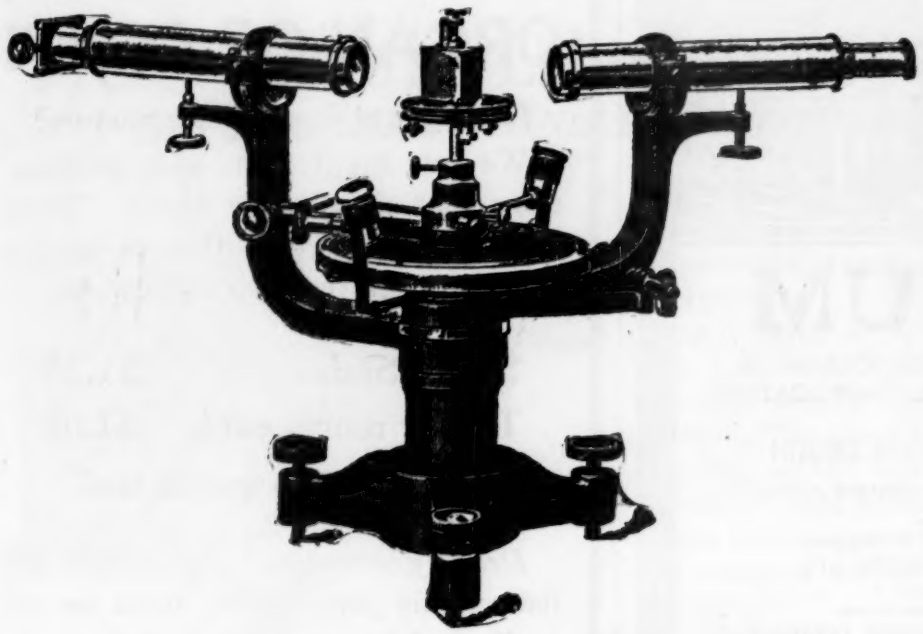

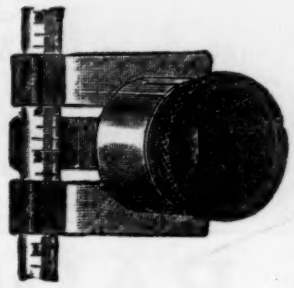

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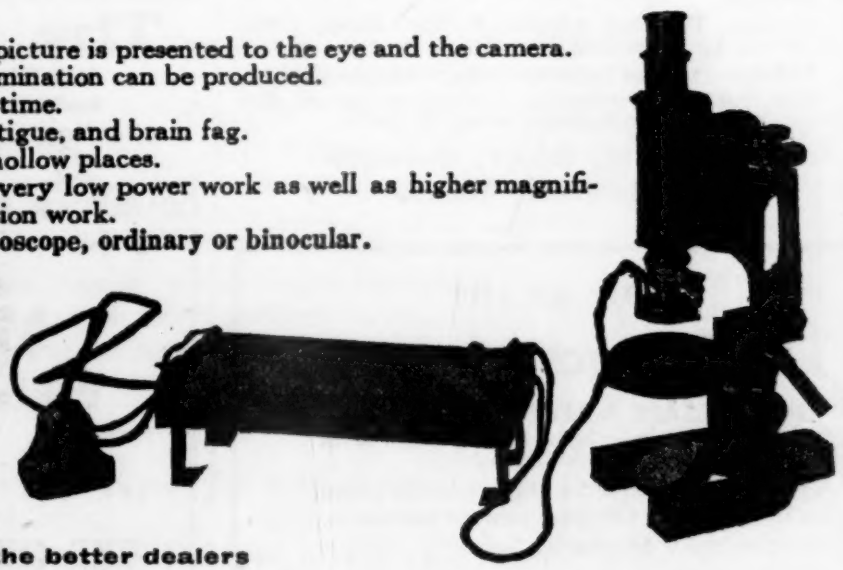

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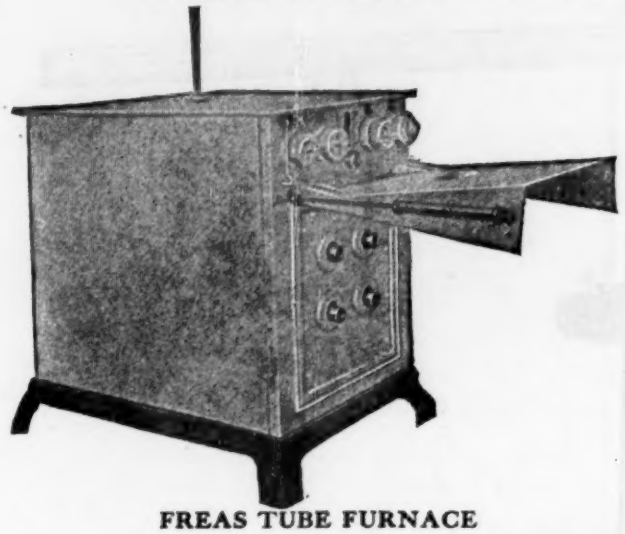

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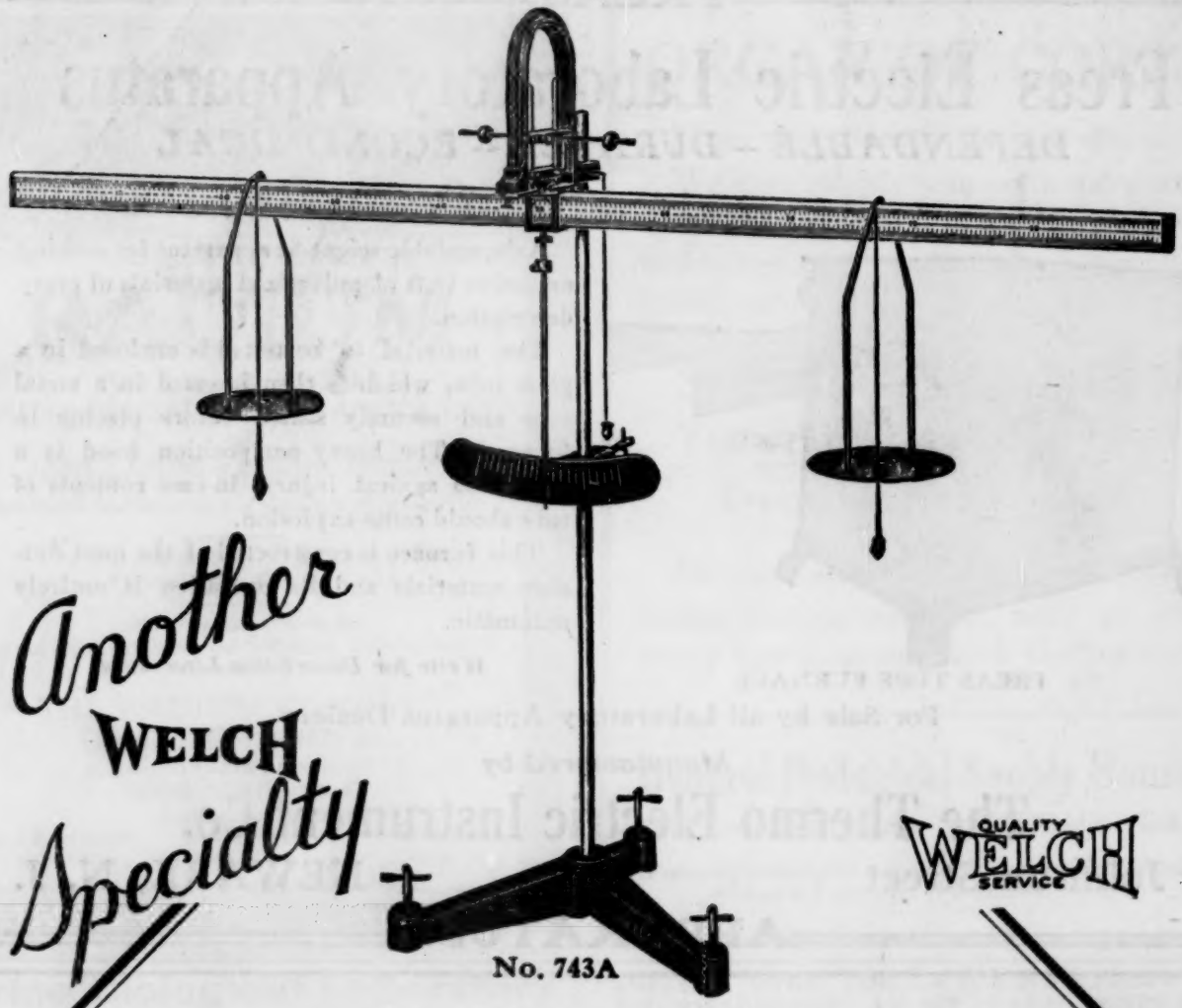

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